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ABSTRACT

This document reports in three volumes the results of a series of surveys designed to: (1) determine what contribution intermediary information transfer organizations such as libraries and information analysis centers make to the value of information; (2) assess the value of two somewhat different software information analysis centers and the value of their products and services; and (3) investigate the importance of timeliness and comprehensiveness to the value of information found in technical reports and journal articles. Data were collected from six surveys. The first was a study of the population of scientists and engineers from nine fields of science conducted as part of a National Science Foundation study. It involved estimating many variables related to authorship, journal use, library use, numeric database searching, and bibliographic database searching. Demographic information identifies scientists and engineers funded by the Department of Energy (DOE). The second, a survey of managers, administrators, operational professionals, and scientists and engineers engaged in research and development at Rocky Flats, Rockwell Energy Systems Group, and Oak Ridge National Laboratory (ORNL), obtained information about general reading, library use, awareness of services, and satisfaction with services. In addition, four surveys were conducted at the three library locations to obtain detailed information about recent uses of specific library materials and services. Detailed analyses including numerous tables and figures present the findings of these studies. (THC)

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A STUDY OF THE VALUE OF INFORMATION AND THE EFFECT ON VALUE OF INTERMEDIARY ORGANIZATIONS, TIMELINESS OF SERVICES & PRODUCTS, AND COMPREHENSIVENESS OF THE EDB

September 1984

King Research, Inc.
Rockville, Maryland

Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy

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Volume 1
The Value of Libraries as an
Intermediary Information Service

Volume 2
The Value of the The Network Energy Software Center
and The Radiation Shielding Information Center

Volume 3
The Effects of Timeliness and
Comprehensiveness on Value

Submitted to:

Office of Scientific & Technical Information
United States Department of Energy
Oak Ridge, Tennessee 37830

Submitted by:

King Research, Inc.
6000 Executive Boulevard
Rockville, Maryland 20852

September, 1984

THE VALUE OF LIBRARIES AS AN INTERMEDIARY INFORMATION SERVICE VOLUME 1

A Study of the Value of Energy Information and Contribution to Value of Materials and Services Provided by Rocky Flats Technical Library, Rockwell Energy Systems Group Library and Oak Ridge National Laboratory Library System

Submitted to:

Office of Scientific & Technical Information
United States Department of Energy
Oak Ridge, Tennessee 37830

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September, 1984

VOLUME 1

THE VALUE OF LIBRAIRES AS AN INTERMEDIARY INFORMATION SERVICE

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SECTION 1
INTRODUCTION

1.1 Background

In 1982 a study was performed for the U.S. Department of Energy Technical Information Center (now Office of Scientific and Technical Information) to investigate the value of information generated from DOE R&D funding and the contribution that the Energy Data Base and its derivative services and products make to the value of this information. The results of the study demonstrated that energy infonnation has substantial value when considered from the standpoints of amount of use, purposes of use, and value measured by what users are willing to pay for the information and the savings in labor, equipment, etc. derived from use of the information. Furthermore, energy information services and products derived from the Energy Data Base clearly contribute greatly to the value of energy information by making it more accessible and, therefore, more usable.

There are two ways to look at the value of energy information. The first perspective involves the $5.8 billion expended by DOE on research and development (in 1981). The return on this investment is achieved through the accomplishment of specific goals and objectives of the R&D and through knowledge that is directly obtained from the research results. The knowledge is also gained by others through information communication and use. It was estimated that approximately 60,000 energy scientists and engineers (funded by DOE) read about 14 million journal articles and reports in 1981. These readings were used for many purposes such as research, professional development, education of others, writing, and management. A survey of energy scientists and engineers showed that many of the readings led to savings of scientists' time and/or equipment used in their research. For readings of articles there was estimated to be an average savings of $590 per reading and for technical reports there was an average savings of $1,280 per reading. When extrapolated to the population of energy scientists and engineers, the total savings yielded from reading came to about $13 billion just for 1981. Thus, energy information production, distribution and use accounts for substantial future savings to DOE scientists.

Presumably, the more energy information is used, the greater will be the return on investment yielded from R&D expenditures.

The second way to look at the value of information is what would happen if the information was not available. The DOE Technical Information Services program managed by the Office of Scientific and Technical Information (OSTI) is designed to provide greater access to energy information. This is accomplished by making copies of energy technical reports available and by providing bibliographic services and products for managing, identifying and locating energy publications. These services and products were investigated in 1981 to determine their contribution to the value of energy information. A very large portion of the 14 million readings mentioned above resulted from use of OSTI services and products. A calculation was made of the amount of readings that would be lost if these services and products were not available. This calculation was made by estimating the average cost per reading from substitute services and products, which nearly always was higher than the average cost of per reading from existing services and products. Thus, at a fixed total budget, fewer readings could be achieved. The loss of readings would, hypothetically, result in less use of the information and therefore, in less value derived from the information.

It was estimated that the corresponding lost value, that is value attributable to the Energy Data Base services and products, was about $117 million in terms of the value determined by what users were willing to pay for the energy information (in price paid and time expended in getting and using the information). Furthermore, in terms of savings, it was estimated that the value was about $3 billion for the value measured by the savings in scientists' time and equipment resulted from reading energy publications. The $3 billion savings in labor and equipment from the EDB products and services can be roughly translated into productivity. If it is assumed that, with the EDB, research and development costs $5.8 billion for a given level of output, without the EDB the same output would require an investment of $8.8 billion. This is an increase in productivity of about 52 percent. This says that to accomplish the same R&D output without TIC information services, the R&D budget would have had to have been $3 billion higher.

The study results were widely disseminated and discussed by economists, the information research community and government policy makers. The study methods were also replicated with similar findings in the Department of Defense and a large corporate information system.

It was felt that the methods and models employed in the previous studies ought to be refined and an additional investigation made to determine what contribution intermediary information transfer organizations such as libraries and information analysis centers make to the value of information. Also, other factors such as timeliness of primary publishing and distribution and comprehensiveness of the Energy Data Base were considered to be important as well. This further investigation was made under a grant from the National Science Foundation with partial contribution by the Department of Energy, Office of Scientific and Technical Information. This volume provides the result of how much typical libraries that serve professionals such as scientists and engineers contribute to the value of information.

In conducting the study we concentrated on library services provided at three locations: Rocky Flats, Rockwell Energy Systems Group and Oak Ridge National Laboratory (ORNL). We also obtained information from a general survey of scientists and engineers found in nine fields of science. The basic approach in this investigation involves estimating the value of energy information using a slightly revised method of calculating value than that used in the previous report.

Section 2 of this report gives an estimate of the amount and purposes of reading of journal articles, technical reports and books in the three locations. The time spent reading is also estimated, which is a major contributing factor to what users are willing to pay for information read. Also, value of information is estimated in terms of what users are willing to pay for it. Finally, value is estimated in terms of what savings (in time and equipment) are achieved from reading.

The amount of value attributable to the libraries serving the three locations above is then estimated. Section 3 provides these estimates which are derived from the amount of reading resulting from the collections and services provided by the three libraries: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System. Alternative sources of information are determined (or subjectively chosen) assuming that the libraries and their services are not available. Then costs are estimated for these substitutes of the library services. These substitutes are nearly always more expensive (or have worse performance). If we assume a given amount of expenditures will be made, the amount of use of information must decrease (because the cost per reading goes up) and, therefore, value will also decrease (in terms of what users are willing to pay and savings derived from reading). Applying the average values and savings derived to the number of lost readings (due to more expensive substitutes) provides the estimates of the contribution that library services make to the value of information.

In Section 4, we give results which describe the performance and effectiveness of library services in the three locations. Performance is measured in terms of (1) the timeliness of services provided and materials delivered and (2) quality of services. Effectiveness is measured in terms of amount of use of specific services and products. Cost effectiveness is given in terms of the cost per use. Of course, value is dependent on amount of use of the materials and services. Finally, in Section 5 we attempt to relate librarian capabilities to performance, performance to effectiveness and performance to value (all for search services). In the case of the relationship between performance and value we use a method, conjoint measurement, to relate relevance of online search results and speed of response to value in terms of user time.

There are two other volumes that report factors that value of information is dependent upon. Volume 2 gives results of a study of two software Information Analysis Centers and the value of software that is attributable to the centers. In Volume 3, we investigate the importance of timeliness to value of information found in technical reports and journal articles. Timeliness is analyzed from the standpoint of the delay of publishing, delay in getting copies of technical reports and articles, delay

in publishing bibliographic databases, and delay in conducting reference searches on-request. That volume also looks at the value of non-U.S. materials and the cross-cutting nature of the subject fields required by DOE scientists and engineers.

1.2 Study Methods

Data were collected from three surveys:

(1) A survey of the population of scientists and engineers from nine fields of science was conducted as part of a study being performed for the National Science Foundation (Statistical Indicators of Scientific and Technical Communication). This survey involves estimating the extent of authorship of journal articles, journal reading, journal subscriptions, technical report reading, library use, numeric data base searching and bibliographic data base searching. Demographic information identifies scientists and engineers who are funded by DOE.

(2) A survey of the professionals employed at Rocky Flats, Rockwell and ORNL was also conducted. This general information usage survey obtained information about general reading, library use, awareness of services and satisfaction with services. It is noted that this survey included managers, administrators and operational professionals as well as scientists and engineers engaged in R&D.

(3) In addition, four surveys were conducted at the three library locations to determine detailed information about recent uses of specific library materials and services: online searches, manual reference searches, journal articles and technical reports. Data collected included sources of services, value of reading, purposes of use, other value related information and, for the two types of searches, conjoint measurement data.

The survey of scientists and engineers actually was done in two parts. The first part obtained information about journal article authorship, reading (i.e., amount, means of identification and access, purpose of reading and value derived from reading), and journal subscriptions. The second part concentrated on technical report reading, library use, and online searching from numeric and bibliographic databases. Samples for both parts were chosen randomly from lists of scientists and engineers provided by professional societies. The first part involved a mail-out of 1,958 questionnaires, of which 1,252 responded (64 percent response rate).

Of these, 588 of the scientists and engineers indicated they were not involved, thus yielding 664 questionnaires that were analyzed. The second part had a mail-out of 1,017 questionnaires of which 467 responses were received and 195 were analyzed. The second survey involved DOE funded professionals (scientists and engineers and others) who work at Rocky Flats, Rockwell Energy Systems Group and Oak Ridge National Laboratories. The professionals were randomly chosen from lists provided by the organizations mentioned above. A total of 200 questionnaires were distributed and 137 received (69 percent response rate). To achieve this level of response the questionnaires were distributed by the libraries (or KRI) to a random sample of professionals who work at the three locations. Some data were collected by telephone follow-up in order to achieve desired response rates. The completed questionnaires were returned to KRI by the respondents by a self-addressed envelope in order to ensure confidentiality.

1.3 Summary of Results

The average annual number of readings per professional by 5,188 professionals at Rocky Flats, Rockwell and ORNL is:

- 99 readings of journal articles
- 44 readings of technical reports
- 15 readings of books

The average time spent annually reading by these professionals and the corresponding cost of this time is:

- 95 hours ($2,600) reading journal articles
- 75 hours ($2,100) reading technical reports
- 63 hours ($1,700) reading books
- 233 hours ($6,400) total reading.

The principal purposes for this reading are as follows (given in ranked order): professional development; applying findings to a current project; applying methods to a current project; writing; preparing proposals; preparing lectures or presentations; and planning, budgeting and management.

The three libraries are used extensively by energy professionals, with average annual uses encompassing:

- 25 uses of the libraries
- 21 times visited one of the libraries
- 17 times read materials in the library
- 10 times photocopied materials in the library
- 11 times checked materials out
- 8 times obtained assistance in locating materials from a library staff person
- 4 times obtained assistance in identifying relevant materials from a library staff member
- 4 times used microform or microfiche equipment
- 2 times obtained materials from other libraries
- Once did a search on library equipment
- Less than once obtained an online bibliographic search and used audio visual equipment.

The amount of annual readings of library materials from all three locations is as follows:

- Journal Articles
  - 53% of all readings came from library materials
  - 53 average annual readings per professional
- Technical Reports
  - 39% of all readings came from library materials
  - 17 average annual readings per professional
- Books
  - 39% of all readings came from library materials
  - 6 average annual readings per professional.

The reasons for extensive use of library materials and services are:

- High awareness of services provided
- Distance from library averages less than 5 minutes
- Library provides access to older materials:
  - 3.5 years average age of journal articles read from library copies
  - 0.6 years average age of articles read from personal subscriptions
  - 1.5 years average age of articles read from other sources
  - 2.4 years average age of technical reports read from library copies
  - 1.2 years average age of technical reports read from other sources
- Some library journal copies are frequently read by professionals rather than subscribing to the journals because of the journal price and/or because they are readily available from the library.

The average value of reading library materials in terms of what users are willing to pay is:

- $41 for reading a journal article
- $102 for reading a technical report.

The total value at the three locations of what users are willing to pay for readings of library journal articles and technical reports comes to:

- $16.6 million, or
- $3,200 per professional.

The average value at the three locations of reading library materials in terms of savings to users is:

- $385 for reading a journal article
- $706 for reading a technical report.

The total value at the three locations of reading library materials in terms of savings is:

- $144 million, or
- $27,700 per professional.

The values attributable to library services are as follows:

- Value in terms of willingness to pay
  - $3.1 million total value attributed to libraries, or
  - $600 per professional
- Value in terms of savings derived from reading
  - $28 million total value attributed to libraries, or
  - $5,400 per professional.

The performance of the libraries is considered to be exemplary in terms of timeliness and quality of service.

Effectiveness measured in terms of user satisfaction is also considered very high.

Indications are that performance of online searching is related to the reference librarian's subject knowledge and search skills. Amount of use is related to performance measured in terms of timeliness and quality of searching. Value in terms of willingness to pay is clearly related to speed of response to search questions and relevance of search results.

SECTION 2

THE USE AND VALUE OF ENERGY INFORMATION

2.1 The Use of Energy Information

There are approximately 5,200 professionals who work at Rocky Flats, Rockwell Energy Systems Group and Oak Ridge National Laboratories (ORNL). These professionals were surveyed by taking a systematic random sample (with random start) from recent telephone listings. A total of 137 persons responded to 200 questionnaires sent out. While it is estimated that most (51%) of these professionals are scientists and engineers engaged in research and development, many of the professionals also have as their primary work role such activities as management and administration (27%), operations (12%), education and training (2%), and other activities (8%). These professionals are generally well educated. Of the respondents to the general information use survey, when asked about highest degree earned, it was found that 14 percent had Doctorate degrees, 25 percent had Master's degrees, 44 percent had Bachelor's degrees and 17 percent had Associate degrees or less.

The professional staff of Rocky Flats, Rockwell and ORNL clearly read a great deal even though not all professionals are scientists and engineers engaged in R&D. Table 1 gives the average and total number of readings of journal articles, technical reports and books by these professionals. The average annual number of readings of journal articles by the professional staff at all three locations is 99 per person. This is somewhat less than the average of 124 annual readings per scientist and engineer observed in the NSF general survey of scientists and engineers across nine fields of science. However, when only persons engaged in research and development are included, the average number of journal article readings comes to 144, which is greater than the amount of reading across the nine fields of science. The amount of reading of technical reports is found to be lower for all professionals (44 readings per year) than for the scientists and engineers generally (78 readings per year).

Table 1
Number of Readings of Journal Articles, Technical Reports and Books by Professionals at Rockwell, Rocky Flats and ORNL - 1983/84

	Journal Article Readings*	Technical Report Readings*	Book Readings*
Average Annual Readings	99	44	15
Total Readings at 3 Sites**	514,000	228,000	78,000

*Readings are defined as going beyond the contents, title and abstract to the body of the article, technical report or book.

**Based on an estimate of 5,188 professionals found at the three sites.

SOURCE: King Research, Inc. - General Usage Survey (n=137)

However, the research and development energy professionals have an average of 69 readings per year. This seems to mean that non-R&D energy professionals do not read nearly as much in the journal literature as those engaged in R&D (67 versus 144 readings per year). This discrepancy in amount of reading is even more pronounced in technical report reading (69 readings by R&D professionals, 26 readings by non-R&D professionals). The number of books read by non-R&D professionals is about one-half the number read by those engaged in R&D (10 readings versus 21 readings).

It is estimated that the energy professionals spend an average of 0.9 hours reading an article, 1.5 hours reading a technical report and 4.4 hours reading a book. This corresponds closely with the findings from the general NSF survey of scientists and engineers. Professionals' time is a scarce resource and they allocate their time to reflect how they can get the most return for their time invested. Thus, the fact that the energy professionals spend about 233 hours a year reading articles, technical reports and books indicates that they consider the information read to be of significant value to them. In fact, their time spent reading is considered a component of what professionals are willing to pay for

information. If we use a typical salary or wage figure that includes other related direct costs*, it is estimated that the average cost of reading per professional is $6,400 per year. The amount of time spent reading is summarized in Table 2. The total cost of time spent reading at the three locations is estimated to be about $33 million.

Table 2
Amount of Time Spent Reading and Cost of Reading Journal Articles, Technical Reports and Books Read by Professionals at Rockwell, Rocky Flats and ORNL - 1983/84

	Journal Article Reading	Technical Report Reading	Book Reading	All Reading
Average Annual Time Spent Reading	95 hours	75 hours	63 hours	233 hours
Average Cost of Time Spent Reading	$2,600	$2,100	$1,700	$6,400
Total Cost of Time Spent Reading	$13.5 million	$10.9 million	$8.8 million	$33.3 million

SOURCE: King Research, Inc. - General Usage Survey (n=137)

The amount of time spent reading varies substantially by the work role of the professionals. For example, the amount of time spent by R&D professionals reading journal articles and technical reports is about double the time spent by non-R&D professionals. Results of the survey concerning these two work roles are given in Table 3 on the next page.

We also determined why the professionals read journal articles and technical reports. The purposes of reading and the proportion of readings conducted for each purpose are summarized in Table 4 on the next page.

* Salary of scientists and engineers is derived from the median R&D salary (Science Indicators 1982) extrapolated by the appropriate GNP Implicit Price Deflator, plus 50% for fringe benefits and other related direct costs. The hourly equivalent to this salary is $27.38/hour.

Table 3
Average Annual Time Spent Reading by Professionals Whose Primary Work Role is Research and Development and by All Other Professionals at Rocky Flats Technical Library Rockwell Energy Systems Group Library, and ORNL Library System - 1983/84

	All Professionals	Research & Development Professionals	Professionals In All Other Primary Work Roles
Journal Articles	95 hours	126 hours	73 hours
Technical Reports	75 hours	111 hours	49 hours
Books	63 hours	76 hours	54 hours
Total Readings	233 hours	313 hours	176 hours

SOURCE: King Research, Inc. - General Usage Survey (n=137)

Table 4
Purposes of Reading and Proportions of Readings of Journal Articles and Technical Reports Read by Professionals at Rockwell, Rocky Flats and ORNL - 1983/84

Purpose of Reading	Journal Articles	Technical Reports
Findings Applied to Project	54%	64%
Methods Applied to Project	43	50
Research Proposal	32	18
Prepare article, book or report	39	45
Reference for article, etc.	25	45
Professional development	62	73
Prepare lecture or presentation	11	18
Planning, budgeting, and management	18	5
Other	4	5

SOURCE: King Research, Inc. - General Usage Survey (n=137)

These purposes of reading by energy professionals correspond to results observed in the general survey of scientists and engineers. Results show that there are several purposes for reading, but the most prevalent ones are for professional development; to apply findings and methods to current projects; and to prepare manuscripts for journal articles, technical reports or books.

2.2 The Value of Energy Information

Obviously, since energy professionals spend so much time reading and for such useful purposes, they must be willing to pay an appropriate amount for the information. The price they are willing to pay in addition to money paid for subscriptions, etc., includes their personal time and effort expended to identify, gain access to and read the articles and technical reports. We have estimated this time and cost associated with readings of library materials. In addition, we asked the professionals to indicate what they would be willing to spend to obtain the article (or technical report), not including their investment of time. This price, which corresponds to consumer surplus in economic terms, is estimated to be $6 per article reading and $56 per technical report reading.* The energy professionals did not have to pay the library for using their journals and technical reports, so the price of the information material was not included in the calculations. The estimates of how much users are willing to pay are given in Table 5.

The average values in terms of willingness to pay are estimated to be about $36 for reading a journal article and about $102 for reading a technical report. Applying these estimates of value (e.g., willingness to pay) we arrive at a total of over $42 million. It is noted that these estimates of value of information include only the cost (or price) borne by the users. They do not include such library costs as purchase of subscriptions, searches performed by reference librarians, etc. The calculations of the average value per reading are subdivided by the appropriate methods

*An outlier of $12,000 was excluded from the calculations.

Table 5
Value of Information in Terms of What Users
Are Willing to Pay - 1983/84

Source of "Willingness" Value	"Willingness" Value Per Reading ($)	Total "Willingness" Value ($)
Journal Readings		
Identification	$ 2.26	$ 1.2 million
Access	3.41	1.8
Reading	24.64	12.7
Additional Value	6.00	3.1
Total	$ 36.31	$18.8 million
Tech. Rpt. Readings		
Identification	$ 1.72	$ 0.4 million
Access	3.65	0.8
Reading	41.07	9.4
Additional Value	56.00	12.8
Total	$ 102.44	$23.4 million

SOURCE: King Research, Inc. - General Usage Survey (n=137)

of identification of materials read. These methods included: by accident while browsing through the library materials, from another person (i.e., a colleague), cited in an article or other publication, cited in a printed index, cited in the output of a computerized literature search, routed by the library, from a library accessions list and other (e.g., article sent by an author for review). Obviously, the time spent by the energy professionals for these methods varied substantially and therefore, was reflected in the estimates.

The second level of value is measured in terms of the consequences that reading and using the information has on research, education and management. A portion of this higher order effect is estimated by asking the energy professionals to indicate if reading a specific recent article or technical report saved them or their co-workers any time on a current task or project. If yes, they were asked to estimate the approximate dollar value of the time saved. They were also asked if there were dollar

savings for other things such as equipment and supply costs. Finally, they were asked to indicate the number of co-workers involved in the savings and how many of them also read the article or technical report. The indication of how many read the article or technical report was determined in order to adjust the estimates of total savings. For example, if two energy professionals on a project read an article, they both would have presumably achieved and reported the savings. Thus, the reported savings are halved. The average savings found by reading journal articles is $385 and the average savings found by reading technical reports is $706. Applying these average values to the amount of reading yields a total estimate of about $360 million value in terms of savings. The average and total savings are given in Table 6.

Table 6
Value of Information in Terms of
Savings to User - 1983/84

Source of Savings Value	Savings Value Per Reading	Total Savings Value
Journal Readings		
Labor Savings	$ 356	$ 183 million
Other Savings	29	15
Total	$ 385	$ 198 million
Tech. Rpt. Readings		
Labor Savings	$ 590	$ 135 million
Other Savings	116	26
Total	$ 706	$ 161 million
Total		$ 359 million

SOURCE: King Research, Inc. - Special Usage Survey (n=137)

It is noted that the average number of people on a project who read the articles and technical reports was very close to two in each instance. Thus, the total estimated reported savings were $770 and $1,412 for journal article readings and technical report readings respectively. The corresponding estimated savings in the 1981/82 energy study were $590 and $1,280 respectively, which seem to be well within statistical limits.

SECTION 3

THE USE AND VALUE OF INFORMATION THAT IS ATTRIBUTABLE TO LIBRARIES

3.1 The Use of Libraries

The libraries (Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System) are extensively used. In fact, the energy professionals at these locations are estimated to use the libraries (or their services) an average of nearly 25 times per year. The libraries are used for a wide variety of purposes as indicated by the average annual uses below:

- 21 times visited one of the libraries
- 17 times read materials in the library
- 11 times checked materials out
- 10 times photocopied materials in the library
- 8 times obtained assistance in locating materials from a library staff person
- 4 times obtained assistance in identifying relevant materials from a library staff member
- 4 times used microform or microfiche equipment
- 2 times obtained materials from other libraries
- Once did a search on library equipment
- Less than once obtained an online bibliographic search and used audio visual equipment.

In terms of the reading of journal articles, technical reports and books, it is found that a substantial proportion of readings came from library copies (see Table 7). In fact, the estimated average annual amount is 53 article readings per professional, 17 technical report readings per professional and 6 book readings per professional. The proportion of readings from library materials observed in the general scientists and engineers survey was substantially lower for both articles (23%) and technical reports (21%).

Table 7
Amount of Readings From Library Copies of Journal Articles, Technical Reports and Books: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System - 1983/84

	Proportion of All Readings	Average Annual Number of Readings/ Professional	Total Annual Number of Readings
Journal Articles	53%	53	275,000
Technical Reports	39	17	88,000
Books	39	6	31,000

SOURCE: King Research, Inc. - General Usage Survey (n=137)

Professionals engaged in research and development read library materials substantially more frequently than non-R&D professionals. Thus, the pattern in which there is more reading by R&D professionals carries into reading of library materials as well, but to an even greater degree. Comparisons of amount of reading of library materials are given in Table 8.

Table 8
Average Annual Readings From the Library Materials by Professionals Whose Primary Work Role is Research and Development and All Other Professionals: Rocky Flats Technical Library, Rockwell Energy Systems Group Library, and ORNL Library System - 1983/84

	All Professionals	Research & Development Professionals	Professionals In All Other Primary Work Roles
Journal Articles	53	85	8
Technical Reports	17	35	5
Books	6	10	3
Total Readings	76	130	16

SOURCE: King Research, Inc. - General Usage Survey (n=137)

Next we calculate the amount of value of information that is attributable to the three libraries. Then, in Section 4, we look into why the libraries are used so extensively.

3.2 Value Attributable to Libraries

The estimated value of energy related information was given in Section 2.2. For the value assessed in terms of user's willingness to pay, the estimated value of an article reading is about $36 and for a technical report reading, about $102. For the value determined by savings resulting from reading, the value for an article reading is about $335 and $706 for a technical report reading. In this section we estimate the amount of this value that is attributable to the library materials and services.

There are estimated to be approximately 211,000 readings of journal articles and 87,000 readings of technical reports provided by the three libraries. The corresponding values of these readings calculated in terms of what users are willing to pay and in savings to the users are given in Table 9 below.

Table 9
Willingness to Pay Value and Savings Value
Directly Attributable to Reading Library Journals and
Technical Reports - 1983/84

($ million)

Source of Value	Willingness to Pay Value	Savings Value
Journal Readings	$ 7.7 million	$ 82 million
Technical Report Readings	$ 8.9 million	$ 62 million
Total	$16.6 million	$ 144 million

SOURCE: King Research, Inc.

These, of course, are not the values that are found by substitutions to the use of library materials. Under normal circumstances, the users could get these materials from other sources. Thus, the values are determined by estimating the cost of using substitute sources for the information and determining the number of readings that would be lost if the total expenditure levels were maintained. The values of the lost readings are what we consider to be the values of the libraries. These values are given in Table 10.

Table 10
Willingness to Pay Value and Savings Value Found by Substituting for the Libraries: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System - 1983/84

($ million)

Source of Value	Number of Lost Readings	Willingness to Pay Value	Savings Value
Journal Readings	47,600	$ 1.7 million	$ 18 million
Technical Report Readings	13,600	$ 1.4 million	$ 10 million
Total	298,827	$ 3.1 million	$ 28 million

SOURCE: King Research, Inc.

An example is given below to show how the calculations are made. Appendix A gives further detail.

The calculation of value begins with a determination of current costs of acquisition, technical processing, identification, access and reading of library materials. This is done for readings associated with various methods used to identify an article or technical report which has been read (such as found while browsing through a library journal or found in an online search output). Obviously, the costs for such methods of identification vary substantially. The average cost of acquisition (including price and technical processing) is $3.94 per reading for journal articles (and $3.53 per reading for technical reports). The cost of identifying an article (which has been read) by means of online searching is $0.68, which includes searches performed by users (16%) and by reference librarians (84%). Access includes the labor cost of an average of eight

minutes to go to the library and back and average cost of photocopying the article ($0.73) which happens about 30 percent of the time. The cost of reading an article is $24.64, so that the total cost of reading an article found by online searching is $33.64. This number is given in Table 11. The total cost of these readings is $536,000 ($33.64 x 15,932).

Table 11

Cost per Reading of Library Copies of Journal Articles and Technical Reports by Method of Identification: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System - 1984

	Journal Articles			Technical Reports		
Source of Identification	Total Readings	Current Cost ($)	Alternate Cost ($)	Total Readings	Current Cost ($)	Alternate Cost ($)
Browsing	86,489	$35.09	$46.78	—	—	—
Colleague	18,208	35.24	42.91	17,432	$47.00	$49.28
Citation	50,072	35.24	42.91	26,147	44.72	49.28
Printed Index	27,312	36.79	49.01	5,811	48.97	60.00
Online Search	15,932	33.64	42.68	7,263	45.31	51.86
Routing	13,656	34.30	46.78	8,716	44.71	51.86
Lit. Acc. List	—	—	—	18,884	47.00	51.86
Other	—	—	—	2,905	44.72	51.86
Total	211,669			87,158		

SOURCE: King Research, Inc.

If there was not a library available, an alternative source would have to be found for identifying and getting these articles in order to read them. The respondents indicated that about 40 percent of the readings

involved unique information (i.e., equally useful information was not known to exist elsewhere). Of that information known to exist elsewhere, 55 percent of the respondents indicated that it was accessible in another library, 18 percent from a colleague, 18 percent from the author and nine percent from the publisher. However, it is noted that in order to duplicate the access when identification is through browsing, another library would have to be employed or the professional would have to subscribe to the journal.

The estimate of the alternative cost of getting journal articles through online searches is estimated to be $42.68. If the budget is set, one could assume that only about 12,559 readings could be achieved through online searching ($536,000/$42.68). Thus, about 3,373 readings would be lost (15,932-12,559). The professionals spend about $28.48 in terms of their time getting the information and they indicate they would be willing to spend $6.00 more for the article, if necessary. Thus, we get a total of $34.48 that they would be willing to pay for a reading. Therefore, the total value of the readings accomplished through browsing would yield a value in terms of willingness to pay of about $116,000 ($34.48 x 3,373). This number is given in Table 12 along with similar values calculated for other methods of identification and for technical report readings. The total value (willingness to pay) for journal article readings is $1.7 million and it is $1.4 million for technical report readings. Together, the average willingness to pay value per energy professional per year is about $600.

The savings value found by substitution materials and services is calculated in a similar manner. For example, the 3,373 readings identified by online searching that would be lost if there was no local library available can be multiplied times the average savings per reading ($385) to get a savings value of $1.3 million. Table 13 gives the savings value which totals $18 million and $10 million for article and technical report readings respectively. This comes to an average savings value of $5,400 per energy professional which is attributable to library materials and services. In a sense, this means that the library materials and services account for about ten percent of the productivity of the energy professionals.

Table 12

Total Library Value Found by Substitution for Library Services in Terms of Willingness to Pay by Method of Identification: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System - 1984

($ millions)

Method of Identification	Journal Articles	Technical Reports
Browsing	$0.787	—
Colleague	0.119	$0.191
Citation	0.327	0.216
Printed Index	0.248	0.126
Online Search	0.116	0.124
Routing	0.132	0.188
Library Acc. List	—	0.322
Other	—	0.048
Total	$1.729 million	$1.384 million

SOURCE: King Research, Inc.

Table 13

Total Library Value Found by Substitution for Library Services in Terms of Savings: Rocky Flats Technical Library, Rockwell Energy Systems Group Library and ORNL Library System - 1984

($ millions)

Method of Identification	Journal Articles	Technical Reports
Browsing	$ 8.3	—
Colleague	1.2	$ 1.3
Citation	3.4	2.7
Printed Index	2.6	0.8
Online Search	1.3	0.9
Routing	1.3	1.3
Library Accession List	—	2.2
Other	—	0.3
Total	$18.2 million	$ 9.5 million

SOURCE: King Research, Inc.

Clearly, the savings value is a "soft" estimate, but probably is in the right order of magnitude. Even so, the extent of number of readings from library materials, time spent by energy professionals in reading these materials and the value determined by what they are willing to pay suggests that library materials and services are extremely valuable.

SECTION 4
PERFORMANCE AND EFFECTIVENESS OF LIBRARIES

4.1 Reasons for Using Libraries

A question arises as to why there is so much use of libraries and so many readings of library materials. To begin with, awareness of the traditional library services is quite high, although analysis reveals that the level of awareness (and usage) of library services varies substantially among specific services. All respondents were aware that they could obtain assistance in locating materials from library staff, and most (84%) had done so at least once. Almost 80 percent of the respondents to the question on online bibliographic searching were aware that this service was available to them through the library, but only 45 percent had made use of this service. The overwhelming majority of respondents (94%) were aware that the library could obtain materials for them from other libraries, but 28 percent of those aware had never done so. However, although all but about three percent were aware that they could obtain assistance in identifying relevant materials from a library staff person, about one-fourth had never done so. About 36 percent of those responding were unaware that the libraries offered audiovisual equipment other than microform equipment. Nearly half of those responding were aware of this service, but had never used it.

Examination of the survey responses reveals, not surprisingly, that the most "conventional" library services are used more often than those that are generally considered less conventional or traditional. For example, personal visits to the library, reading materials in the library, photocopying materials in the library, checking out materials, and obtaining assistance in locating materials were performed an average of 21, 17, 10, 11, and 8 times respectively in the last year by respondents. On the other hand, respondents used microform equipment an average of fewer than 4 times in the last year, used both other audiovisual equipment and had an online bibliographic search performed by them by the library an average of less than once during the past year, and performed a search on

library equipment an average of less than once. Interlibrary loan, a fairly conventional service, was performed by the library an average of only twice in the past year per professional. This, however, may possibly be due to the sufficiency of the library's own collection for the majority of needed items, and when multiplied by the number of patrons, results in a sizable volume of interlibrary borrowing. Another conventional service, obtaining assistance in identifying relevant materials, was carried out by respondents on an average of four or so times in the last year. More than 25 percent of the respondents were aware of this service.

Another factor that enters into high library use and readings of library materials is that a high proportion of the professionals at the three locations are located near a library. In fact, over 60 percent of the professionals are within five minutes of their library and over 75 percent within ten minutes. The significance of the distance (in time) is portrayed in Figure 1. It is shown that energy professionals who are less than five minutes to the library average 8.8 visits a month to the library. When the energy professionals are located over ten minutes away, the average number of times they visit the library drops to below once a month. However, the number of uses of the library per month only decreases from about seven uses per month for those under five minutes away to about four uses for those over ten minutes away.

Materials read in libraries are, on the average, quite a bit older than materials read from other sources. This suggests that energy professionals rely on their libraries to gain access to older articles and technical reports. The age of readings is given in Table 14 for journal articles and technical reports.

The average age of journal articles read from library copies is 3.5 years compared to less than a year for articles read from personal subscriptions and 1.5 years for articles obtained from other sources. Similarly, the average age of technical reports read from library copies, 2.4 years, is double that of technical reports read from other sources (1.2 years).

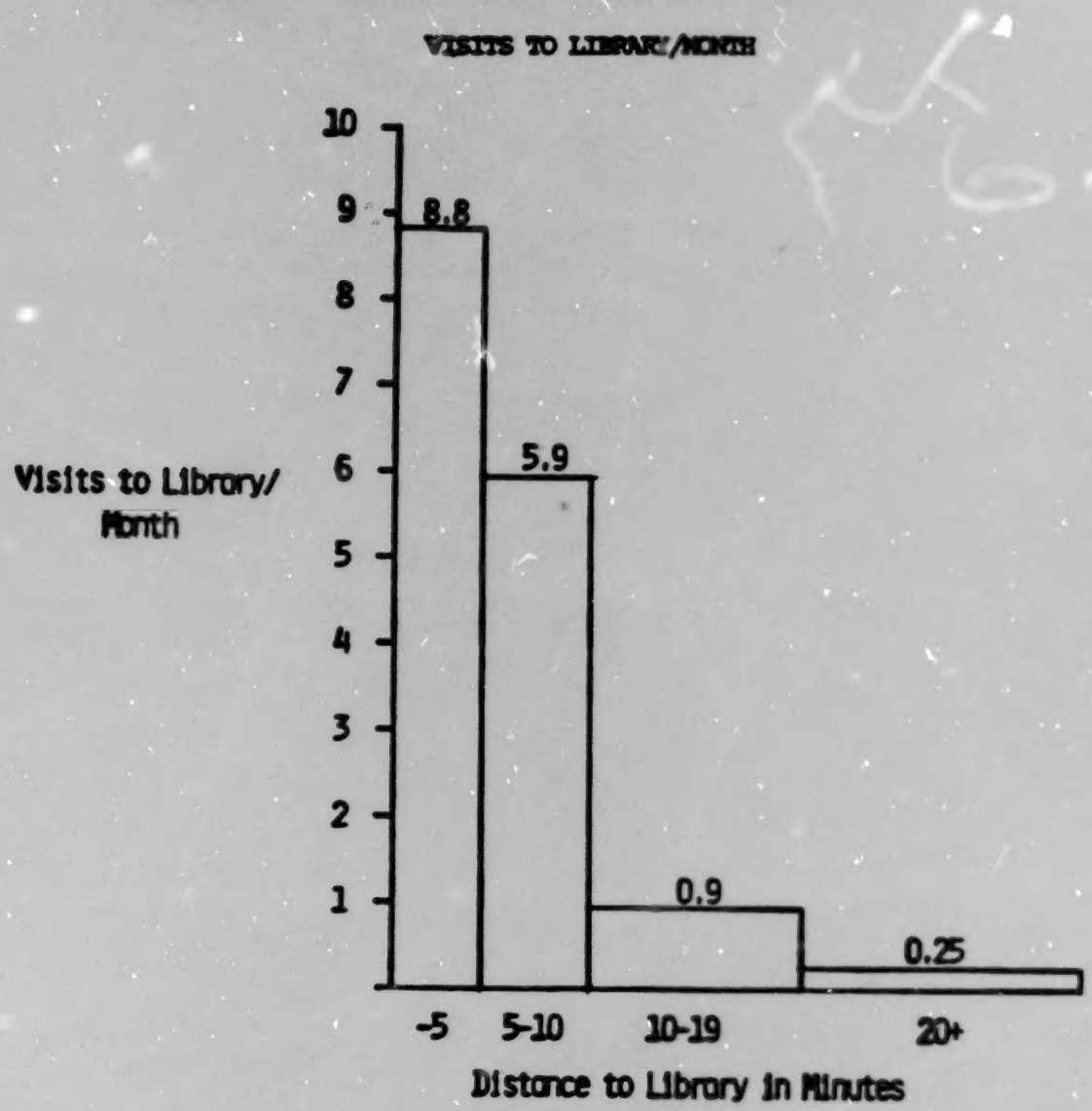

Figure 1. Number of Visits to the Library Per Month as a Function of Distance to the Library in Minutes

Table 14
Proportion of Readings in Libraries and Readings from Other Sources by Age of Publications - May 1984
(%)

Year	Journal Articles*			Technical Reports**	
	Library Copy	Personal Subscriptions	Other	Library Copy	Other
1984	41%	84%	69%	50%	48%
1983	16	10	13	19	30
1982	8	3	6	0	8
1977-81	22	1	13	19	13
1972-76	5	1	6	13	2
1962-71	5	1	0	0	0
<1962	3	0	0	0	0
Average Age	3.5 years	0.6 years	1.5 years	2.4 years	1.2 years

SOURCE: King Research, Inc. - Statistical Indicators Survey (n^{*}=195, n^{**}=664)

Another factor which contributes to the reading of library materials has to do with the number of journal subscriptions taken by the energy professionals. If the professionals do not subscribe to many journals, they are more likely to get access to their frequently read journals from other sources. For example, scientists were asked to indicate whether there are any journals from which they read at least ten articles per year to which they do not personally subscribe. Of those who said yes (about one-half), the average number of subscriptions received by them was 3.3 compared to 5.8 subscriptions for those who said no. Of the subscriptions received, about two-thirds were paid for by the scientist. The remaining were mostly paid by their employers. The relationship here was about two to one for yes to no. These results are displayed in Table 15.

Table 15
Average Number of Subscriptions for Scientists
Who Do and Do Not Gain Access to Frequently Read Journals
(Over Ten Articles Per Year) - 1984

	Scientist Read at Least Ten Articles Per Year From Journals to Which He Does Not Personally Subscribe	
	Yes	No
Average Total Personal Subscriptions	3.3 subscriptions	5.8 subscriptions
Average Subscriptions Paid By Scientist	2.3 subscriptions	4.5 subscriptions

SOURCE: King Research, Inc. - Statistical Indicators Survey (n=167)

Of the scientists who frequently read journals to which they do not subscribe, most of them (76%) get them from the library. As shown in Table 16, the reasons for not subscribing to the journal are the price of the journal (66%) and because it is readily available from the library (61%). Thus, there appears to be an economic reason for the high level of reading library materials.

Table 16
Proportion of Scientists Who Frequently Read Journals to Which They Do Not Subscribe By Sources of These Journals and Reasons for Not Personally Subscribing to Journal - 1984

	Proportion of Scientists (%)
Sources of Journals	
Borrow from Colleague	21%
Library Copy	76
Other	3
Reasons for Not Personally Subscribing to Journal	
Readily Available from Colleague	10%*
Price of Journal	66
Readily Available from Library	61
Other	3

*Proportions do not add to 100% since respondents could have more than one reason.
SOURCE: King Research, Inc. - Statistical Indicators Survey (n=167)

4.2 Library Performance

One aspect of library performance deals with the output of services provided. This output has been given in terms of amount of materials provided, number of searches performed and so on as part of the value calculus in the previous sections. Other measures of performance of the libraries include timeliness and quality. The timeliness of online and manual searching is measured by subtracting the time necessary to get the search output from the required amount of time to get it. In about 78 percent of the searches the output was delivered on time or ahead of the required time. Thus, about one-fifth of the search results were delivered after the required time. The average amount of time of late deliveries, for those delivered after the required time, was about 6 days. Quality is assessed below from the user's perspective of their satisfaction with various library services.

4.3 Library Effectiveness

Library effectiveness is determined from the perspective of the library users. It includes such measures as amount of use and user satisfaction with the services. We have discussed amount of library use in previous sections so that it is not repeated here. However, user satisfaction was obtained in the general usage survey. Energy professionals were asked to rate their general satisfaction with library services. Only library users were asked to respond to these questions. A summary of satisfaction with specific library services are given below in Table 17.

Table 17
Proportion of Professionals Who Indicated Various Degrees of Satisfaction With Library Services: Rocky Flats Technical Library, Rockwell Energy Systems Group Library, and ORNL Library System - 1984

	(1) Very dis-satis-fied (%)	(2) Dis-satis-fied (%)	(3) Neither satis-fied nor dis-satis-fied (%)	(4) Satis-fied (%)	(5) Very satis-fied (%)	Average Satis-faction Score
Assistance in acquiring materials	0	0	9	30	61	4.52
Assistance in locating materials from a library staff member	1	0	5	29	64	4.52
Assistance in in searching for relevant materials by a library staff member	0	0	8	39	54	4.50

Table 17 (Continued)

	(1) Very dissatisfied (%)	(2) Dissatisfied (%)	(3) Neither satisfied nor dissatisfied (%)	(4) Satisfied (%)	(5) Very satisfied (%)	Average Satisfaction Score
Microform reading/ printing equipment available	3	3	20	41	33	3.98
Collection of monographs, reports, journals available for reading in the library	0	6	12	40	43	4.23
Staff Assistance in Locating and Obtaining Materials						
Level of library staff knowledge	0	0	4	42	54	4.50
Speed of providing assistance	0	0	8	41	52	4.48
Speed of acquiring materials	2	6	22	40	29	3.85
Online Bibliographic Searching						
Relevance of output to your information needs	0	2	23	41	34	4.07
Number of references in search output	0	0	17	50	33	4.16
Time between your request and your receipt of search output	0	0	9	52	39	4.30

Table 17 (Continued)

	(1) Very dis-satis-fied (%)	(2) Dis-satis-fied (%)	(3) Neither satis-fied nor dis-satis-fied (%)	(4) Satis-fied (%)	(5) Very satis-fied (%)	Average Satis-faction Score
Searcher's technical performance (facility with and knowledge of search techniques and vocabulary)	0	0	5	45	50	4.45
Searcher's knowledge of subject field searched	0	0	26	47	28	4.06
Cost of having search performed	4	0	46	33	17	3.59
Obtaining Materials from Other Libraries (e.g., interlibrary loan)						
Time interval between your request of the materials and your receiving them	2	5	28	45	22	3.86
Cost of obtaining materials from other libraries	3	3	24	45	26	3.91
Packet of Materials Prepared for you by a Library Staff Member on a Specific Subject						
Number of items in the packet	0	0	12	65	24	4.16

Table 17 (Continued)

	(1) Very dis-satis-fied (%)	(2) Dis-satis-fied (%)	(3) Neither satis-fied nor dis-satis-fied (%)	(4) Satis-fied (%)	(5) Very satis-fied (%)	Average Satis-faction Score
Relevance of items in packet to your information needs	0	0	6	72	22	4.16
Currentness of items in the packet	0	6	6	50	39	4.25
Speed at which the packet was prepared	0	0	22	33	44	4.18

SOURCE: King Research, Inc., General Usage Survey (n=137)

Satisfaction with specific library services, was generally fairly high. Average satisfaction scores ranged from a low of 3.59 (cost of having search performed) to a high of 4.52 for assistance in (1) acquiring and (2) locating materials. However, a small proportion of respondents noted some dissatisfaction with assistance in locating materials (1%), microform reading/printing equipment available (6%), and the collection of monographs, reports, and journals available for reading in the library (6%), respectively. Not surprisingly, the highest percentage of "less than satisfied" responses (just over 26%) fell into the category of microform reading/printing equipment. It should be noted, however, that nearly 18 percent of the responses dealing with collection of monographs, technical reports, journals, etc., also falls into the "less than satisfied"

category. In contrast, none of the respondents who had used the services in the past year rated themselves as dissatisfied or very dissatisfied with assistance in acquiring materials and with assistance in searching for relevant materials.

Satisfaction with staff assistance in locating and obtaining materials was also fairly high. However, the responses to speed of acquiring materials show the highest level of "less than satisfied", with two percent of respondents feeling very dissatisfied, six percent feeling dissatisfied, and 22 percent neither satisfied nor dissatisfied.

Levels of satisfaction with online bibliographic searching performance attributes reveal that the majority of those respondents for whom the library had performed a search in the past year felt satisfied or better with the performance attributes of relevance of output, number of references in search output, time between request and receipt of search output, searcher's technical performance and searcher's knowledge of subject field searched. However, only 50 percent of those responding in terms of a level of satisfaction with the cost of having search performed felt satisfied or better, with nearly 46 percent feeling neither satisfied nor dissatisfied. Although the majority of respondents (74%) felt satisfied or better about the searcher's knowledge of the subject field searched, another 26 percent were neither satisfied nor dissatisfied with this performance attribute.

Levels of satisfaction with performance attributes associated with obtaining materials from other libraries indicate that the majority of respondents felt satisfied or better (66%, 71%) with the time interval between their request of materials and their receiving them, and with the cost of obtaining materials from other libraries. Interestingly enough, about one quarter of the respondents (28% and 24%) felt neither satisfied nor dissatisfied about the time interval and the cost involved in obtaining materials from other libraries.

Satisfaction with performance attributes associated with packets of materials prepared by library staff on a particular subject is generally high. However, it should be noted that the number of respondents actually rating their level of satisfaction with packets of materials is quite low, as the number of respondents who had not used this service within the last year was uniformly high. This low degree of usage might bear further investigation as one could hypothesize that respondents who indicated they had not used the service may not have been aware of its availability. For only one performance attribute, currentness of items in the packet, do those respondents who have received a packet express dissatisfaction - not quite six percent were dissatisfied with the currentness of items in the packet.

When asked to rate the library's collection, 73 percent of those doing so felt that the collection was complete enough for their needs, with the remaining 28 percent rating the collection as not complete enough for their needs. Those respondents replying in the negative made comments on the library collection's shortcoming that were diverse and fairly specific, ranging from comments like: "need more materials on subject x", "library's x are not current", to "materials I need always seem to be on loan and not available". Some respondents also took the time to include positive comments and/or to indicate satisfaction with certain types of library materials in this area.

Responses to the question which deals with whether or not respondents have received unsolicited materials from the library and asks them to rate the level of usefulness of these materials, are noteworthy in that the majority of respondents consistently indicate that they had not received these unsolicited materials. (Whether or not this is indeed the case, or whether a higher proportion of respondents had indeed received unsolicited materials from the library but did not realize this fact can not be ascertained.) Of all three types of unsolicited materials, only general information was received by more than 10 percent (36%) of those responding.

It is noted that ratings of level of usefulness given here should be treated with caution. Of those that had received unsolicited general information, 88 percent rated it as useful, and six percent as not useful. Those who had received an unsolicited literature search differed as to its usefulness: 22 percent rated it as not useful and 78 percent as useful. On the other hand, all of those receiving objective analyses of issues of current high interest rated them as useful.

Responses to library usage appear to indicate an acceptable level of satisfaction, and a fairly high volume of usage for "conventional" services, etc., for the most part. However, one might hypothesize that library patron lack of awareness, both of the availability of certain specific library services, and of when they are actually receiving library services/materials (especially those that are unsolicited) may well need improvement.

SECTION 5

RELATIONSHIP OF PERFORMANCE TO EFFECTIVENESS TO VALUE

5.1 Introduction

An attempt is made in this section to relate some librarian capabilities to their performance, performance to effectiveness, and performance to value. All of the analysis deals with online and manual bibliographic searching. The librarian capabilities investigated include their knowledge of the subject in which specific searches are performed and their technical searching skills (i.e., facility with and knowledge of search techniques and vocabulary). Performance is measured by timeliness of response to search, relevance of output to information needs and number of references in search output. Effectiveness is measured in terms of user satisfaction and number of searches performed per month. These relationships are given in Section 5.2 and 5.3. In Section 5.4, a trade-off analysis is performed in which user time (i.e., willingness to pay value) is determined as a function of response time and quality of search in terms of relevance of output.

5.2 Relationship of Librarian Capabilities to Performance

The first correlation is done between ranking of the searcher's knowledge of the subject field searched and satisfaction with relevance of output. The searcher's qualification in terms of knowledge of the subject field searched is found by having the user rank this knowledge from not well qualified (rank of 1) to very well qualified (rank of 5). This ranking was done for a specific search. The users were also asked to indicate their degree of satisfaction with the relevance of items identified to their information needs.* This relationship between the capability and performance is depicted in Figure 2 which shows that rankings of the searcher's knowledge at level two, on the average, yields a dissatisfaction with the search (i.e., satisfaction score of two).

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* Possibly a better means of observing the capabilities and performance would be an expert in the field and not the user. However, there are arguments for both methods.

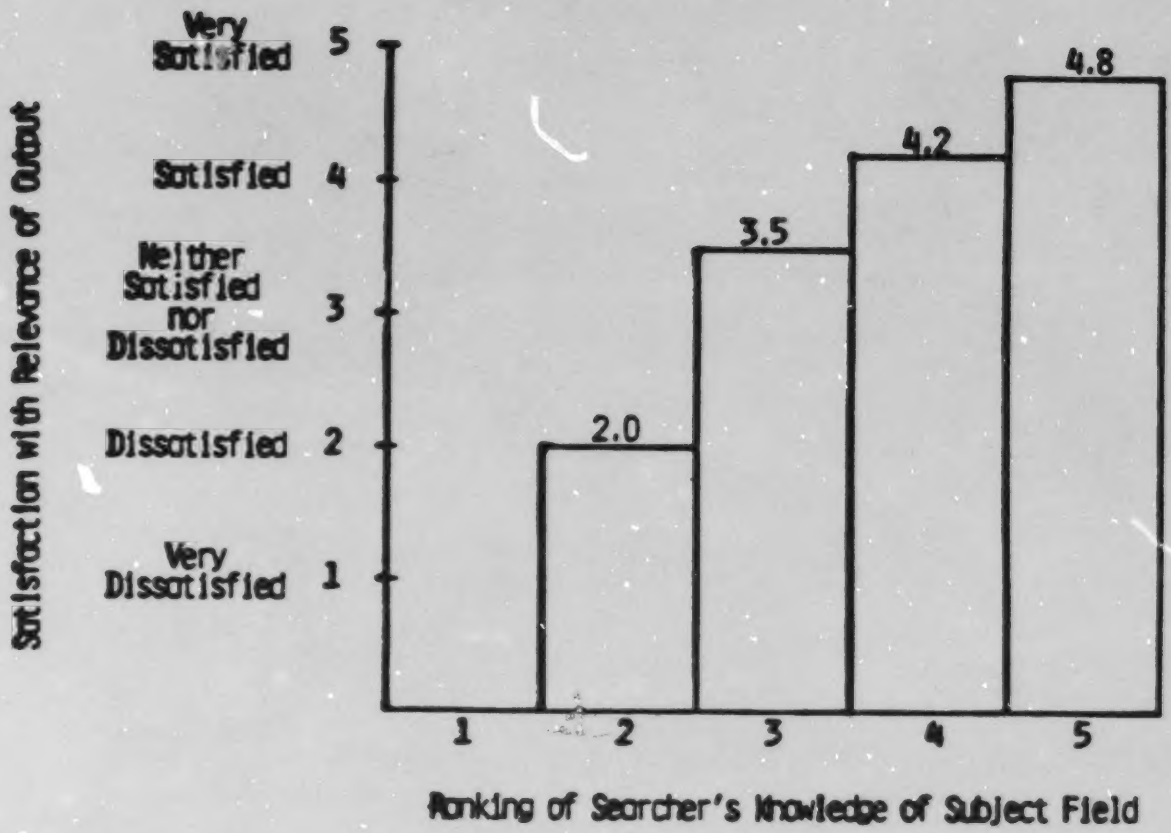

Figure 2. Relation of Search Performance as a Function of the Searcher's Knowledge of Subject Field

However, as the ranking of searcher's knowledge increases, the level of satisfaction increases to the point where a ranking of searcher's qualification in terms of subject knowledge of five yields an average satisfaction score of 4.8.

Similarly, higher rankings of searcher's technical skills yield higher satisfaction with relevance of output (Figure 3). However, the levels of satisfaction with relevance of output are generally not as high as those observed with the searcher s knowledge of the subject field searched. Thus, one would conclude that the searcher s subject knowledge is probably more important than the searcher s technical skill.

5.3 Relationship of Performance to Effectiveness

Another important relationship is between speed of delivery (performance) and satisfaction with speed of delivery (effectiveness). The chart in Figure 4 shows that energy professionals are dissatisfied (2.0) if the search results are delivered more than five days beyond the required time indicated by the user. On the average, they are satisfied (4.2) if the delivery is not over five days beyond the required time. If the results are delivered ahead of the required time, the users, on the average, are close to being very satisfied (4.8).

In this section, we also show that amount of use of library services is related to individual measures of performance (specified by the users). The measures of performance include satisfaction with relevance of output, number of references retrieved and timeliness of responses. First we show that average number of online searches performed per year for users is related to satisfaction with relevance of output. The chart in Figure 5 shows that users who are dissatisfied with relevance of search output, on the average, ask for searches only 1 1/2 times per year. Whereas users who are very satisfied with relevance of output ask for searches an average of 3.2 times per year. Referring back to the searcher s knowledge of the subject field searched, a low ranking (2) resulted in the user being dissatisfied and a high ranking (5) yielded a score close to being very satisfied. Thus, one might convert low searcher knowledge to 1.5 searches

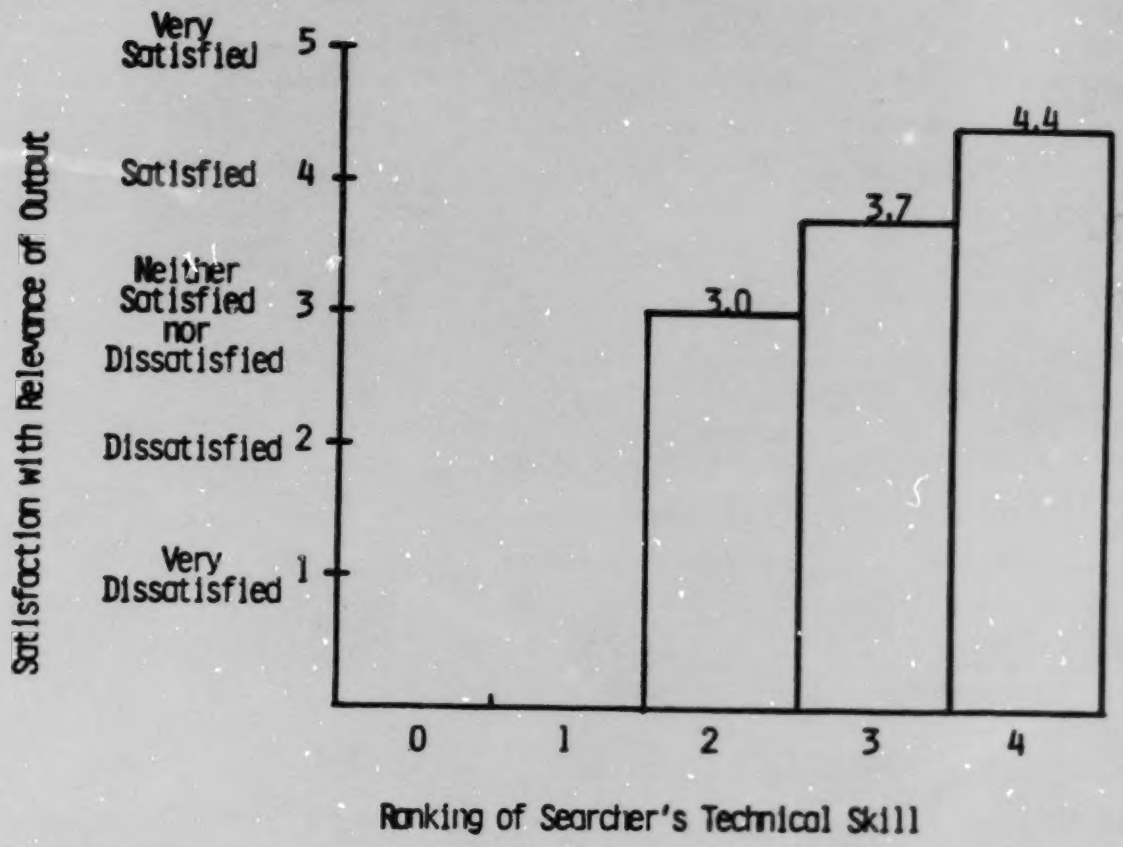

Figure 3. Relation of Search Performance as a Function of the Searcher's Technical Skill

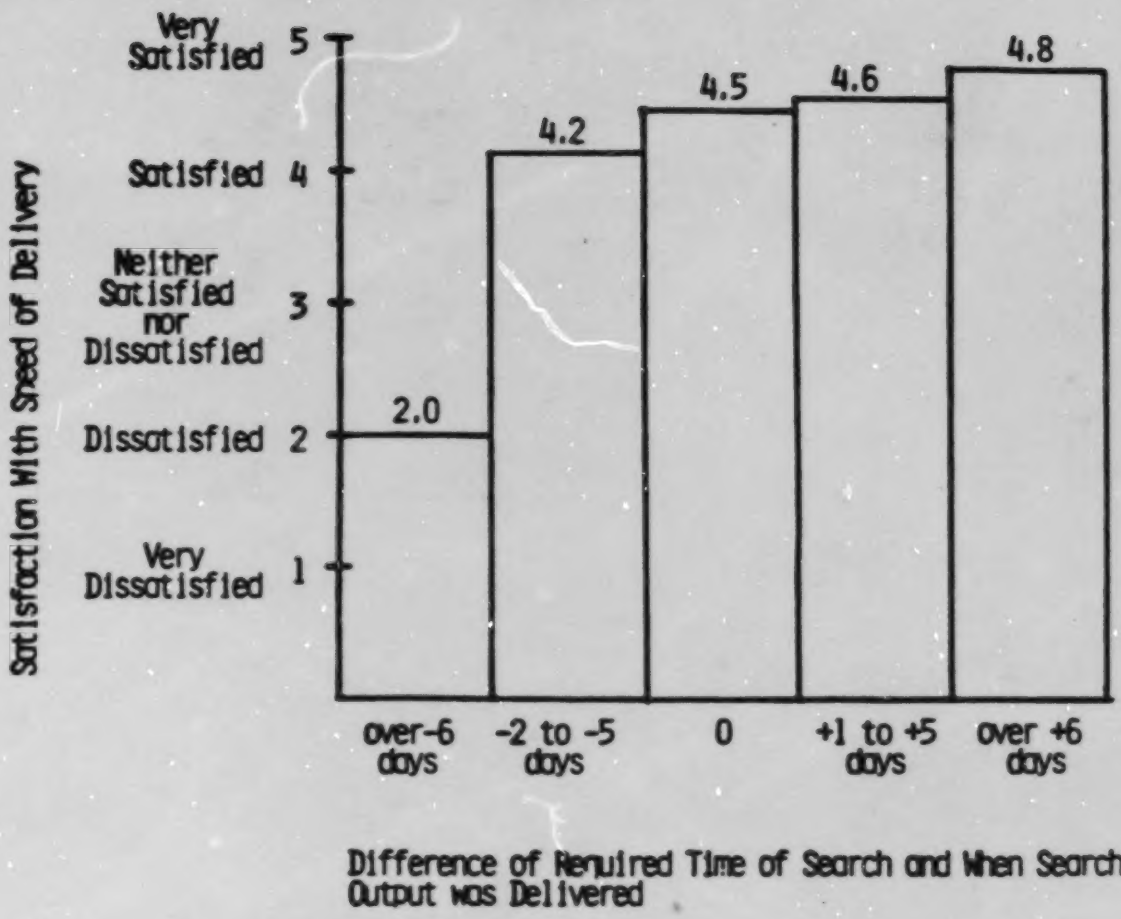

Figure 4. Relation of Search Effectiveness as a Function of Speed of Delivery

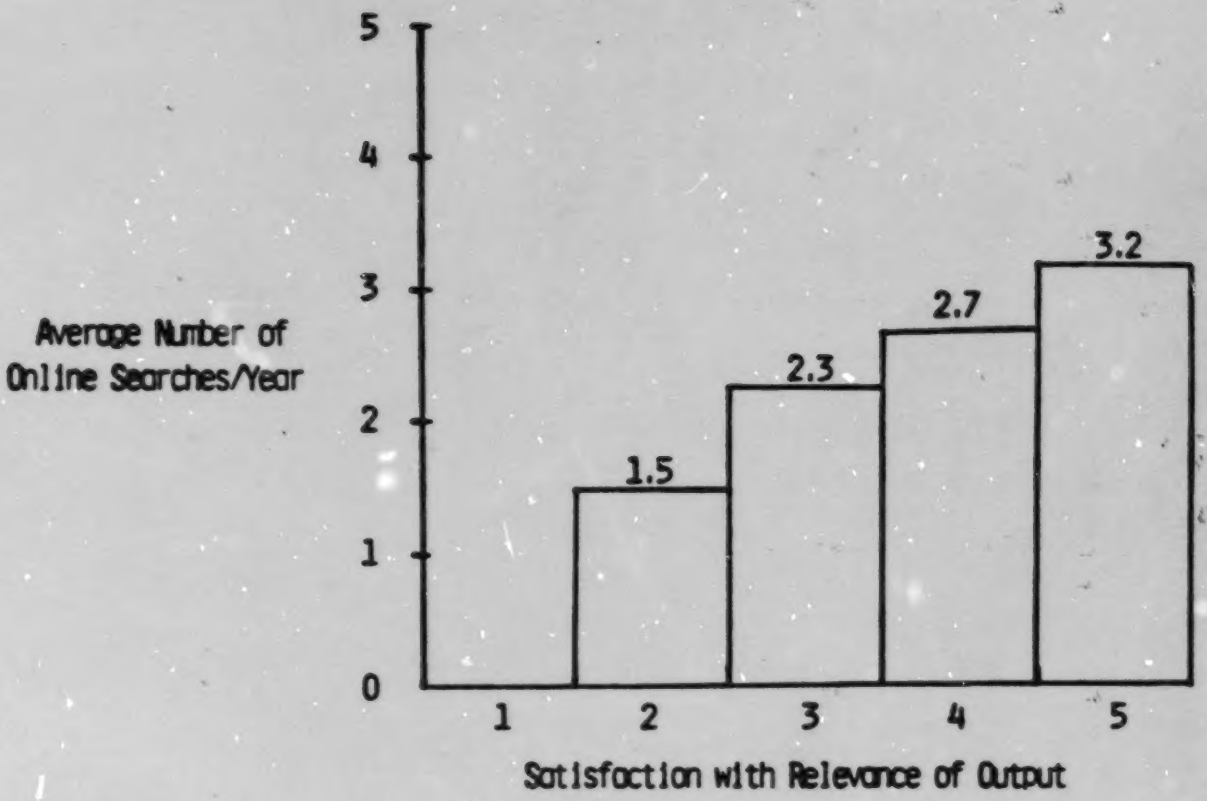

Figure 5. Relation of Number of Searches Performed as a Function of Performance in Terms of Relevance of Output

per year and high searcher knowledge to about 3.0 searches per year. These numbers, in turn, could be converted to value since fewer (or more) searches directly affect use of primary information, and hence, value.

Similarly, the average number of online searches requested per year is related to satisfaction with number of references retrieved (Figure 6) and satisfaction with timeliness of search response (Figure 7). However, these relationships do not appear to be as strong as the relationship of number of searches performed and relevance of search output. For example, the average number of searches performed per year for those who are generally dissatisfied and for those who are very satisfied is 2.0 searches per year and 2.8 searches per year respectively, thus showing a difference in the average of less than one search per year. As one would expect, the average number of searches performed per year for those who are neither satisfied nor dissatisfied (2.0 searches per year) is lower than the number performed per year for those who are very satisfied (3.2 searches per year).

5.4 Tradeoff of Performance and Value

In the previous sections we were able to demonstrate a relationship between number of searches requested and, independently, performance attributes such as timeliness and quality of online searching. The problem is that one does not know the relative contribution these performance attributes have when considered together. In this section we give an analysis of how timeliness and quality together affect the value of searching expressed in terms of user time (i.e., their willingness to pay). The analysis is performed using a statistical method called conjoint analysis.

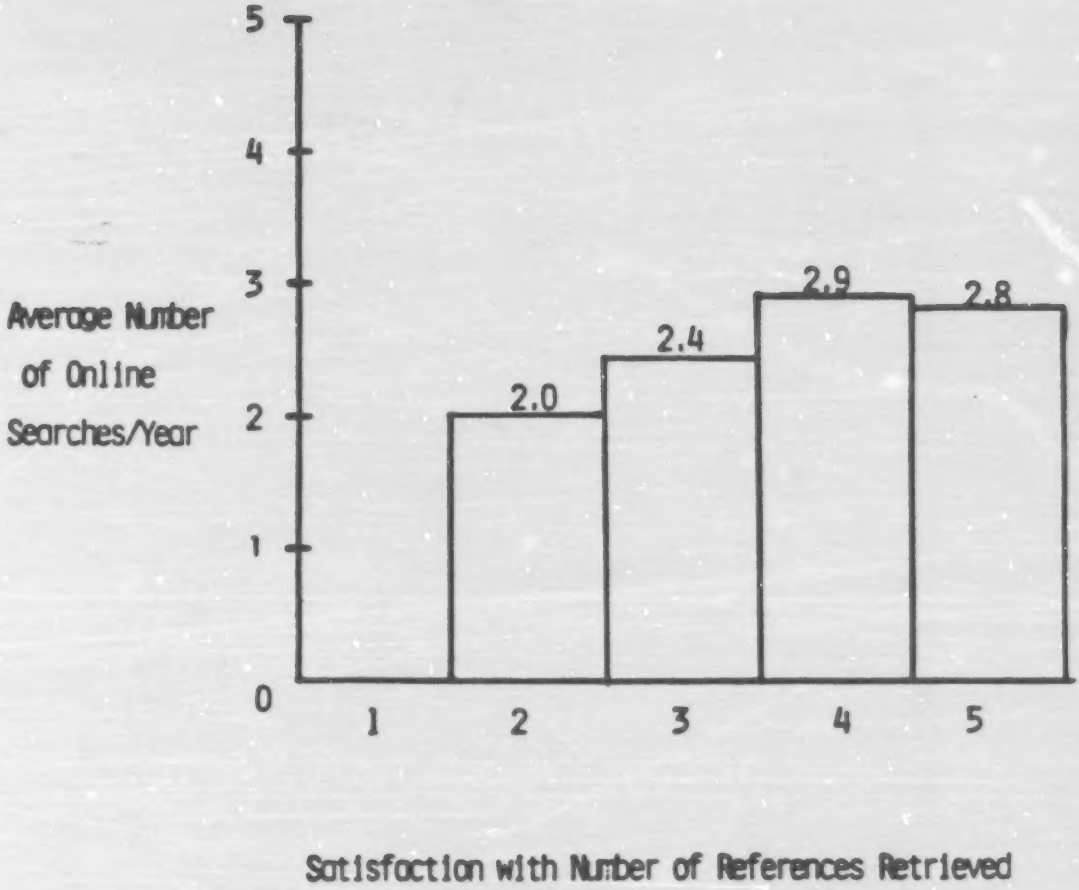

Figure 6. Relation of Searches Performed as a Function of Performance in Terms of Number of References Retrieved

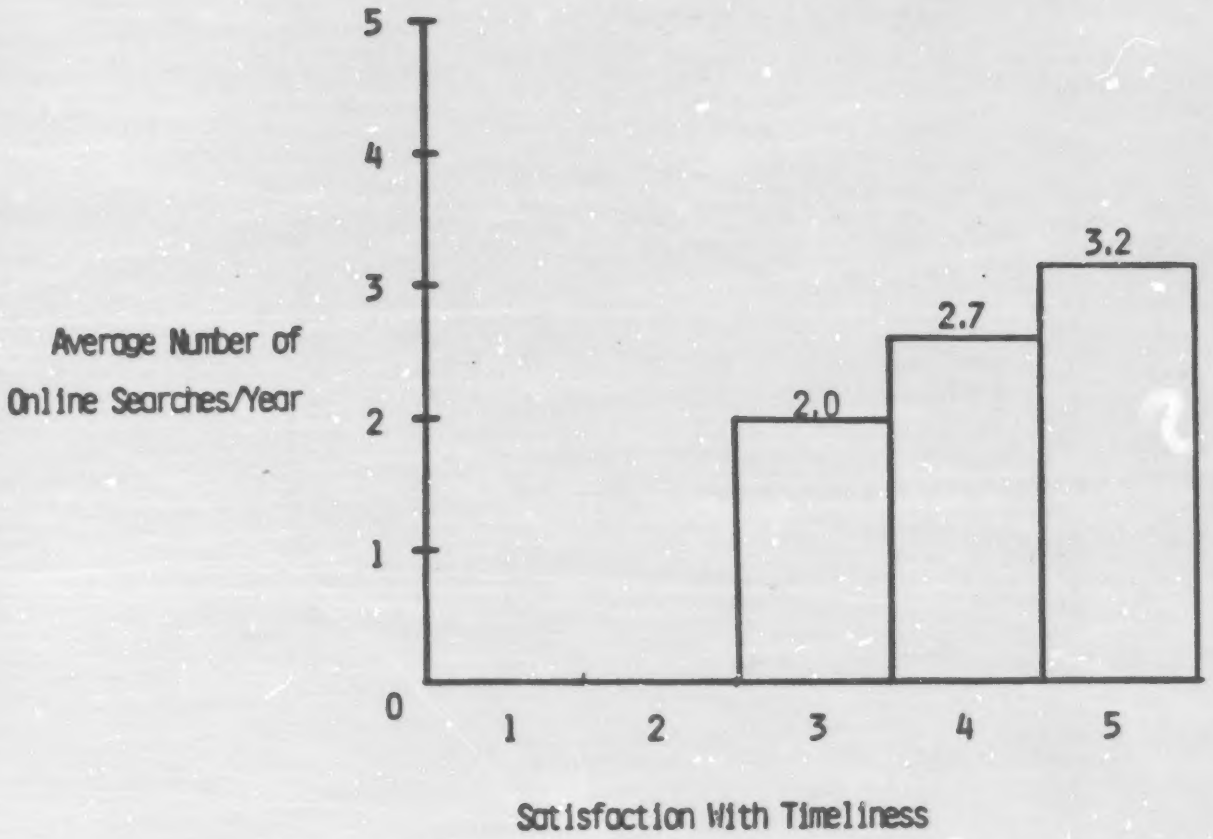

Figure 7. Relation of Number of Searches Performed as a Function of Performance in Terms of Timeliness

Conjoint analysis is a marketing research tool developed to aid system managers in estimating the relative importance of number of system performance attributes. This method requires potential users to make overall judgements about a set of complex alternatives involving different combinations of the system performance attributes. This is done by having the users rank their preference for the various combinations of system performance attributes. These rankings are then used to arrive at a set of utility scales for the system attributes that are compatible with original overall rankings.

In our particular situation, there are three factors that are expected to influence users' preference: price (in terms of user time), quality of search, and speed of response. Here we consider three levels of price (less than a half hour, between 1/2 and 1 hour, and between 1 and 2 hours) and quality of search (high relevance, medium relevance and low relevance of items retrieved). Three different speeds of response are also considered (within a day, between 1 and 3 days, and over three days). Value is determined by what users are willing to pay in terms of their time. Since it has been shown that the value of library services is partially determined by saving user's time (a scarce resource), the survey respondents were asked to think of the "price" paid for searches performed for them in terms of their time.

The data collection for conjoint analysis requires that professionals indicate the relative importance of the "price" and performance attributes by comparing pairs of the "price" and attributes, one at a time. Each pairwise comparison focuses on two of the three factors and, in effect, ignores the remaining one factor by not specifying it. Table 18 summarizes the alternatives or levels for each of these three factors.

Table 18
Performance Attributes, "Price" and Their Levels

Performance Attributes	LEVEL Number	Description
Quality of Search	1	not specified*
	2	high relevance of items
	3	medium relevance of items
	4	low relevance of items
Speed of Response	1	not specified*
	2	within 1 day
	3	between 1 and 3 days
	4	over three days
"Price" in terms of User's Time	1	not specified*
	2	1/2 hour
	3	1/2 to 1 hour
	4	1 to 2 hours

* Not specified means that the factor is not one of the two factors included in the pairwise comparison.

Next, we summarize the survey results for rankings made by users. The mean (or average) rank, as well as the minimum and maximum ranks for each pairwise comparison, is presented. If the mean rankings are arranged in order, we have a reasonable impression of how most respondents completed their questionnaires. The minimum and maximum values indicate the spread in their responses.

In the matrix below, we give performance attributes: quality of search and "price" in terms of user time. The professionals ranked the nine combinations of levels from 1 to 9. Presumably, the highest rank (1) is high relevance at a "price" of only 1/2 hour. The lowest rank (9) is low relevance at a cost of 1-2 hours. The remaining cells were ranked from 2 to 8. In the matrix we show the average ranked value and minimum and maximum ranks observed in the survey.

Quality of Search	"Price" in Terms of User Time		
	1/2 hour	1/2 - 1 hour	1-2 hours
High relevance of items	1 (1, 1)	2.10 (2, 4)	3.63 (3, 7)
Medium relevance of items	3.73 (2, 6)	4.95 (4, 6)	6.33 (4, 8)
Low relevance of items	6.50 (3, 7)	7.78 (6, 8)	9 (9, 9)

Generally, users ranked second the cell of high relevance and "price" at 1/2 hour to 1 hour. This suggests that high relevance is more important than the price paid in terms of the user's time. However, at the price of 1 to 2 hours about one-half of the respondents preferred lower relevance (medium). This is where the price becomes more important than relevance.

On the next page are two other attributes: speed of response and price in terms of user time. The cells are also ranked 1 to 9. Again, average ranks (and minimum and maximum) are presented.

Speed of Response	Price in Terms of User Time		
	1/2 hour	1/2 - 1 hour	1-2 hours
W/in Day	1 (1, 1)	2.75 (2, 4)	4.97 (3, 7)
W/in 3 days	2.97 (2, 4)	4.81 (3, 6)	7.06 (6, 8)
Over 3 days	5.25 (3, 7)	7.19 (6, 8)	9 (9, 9)

Here the second choice was clearly split between (1) the choice of speed within the day and "price" at 1/2 to 1 hour and (2) the choice of speed within three days and "price" at 1/2 hour. Thus, speed does not appear to be as important as compared to relevance of search items when users are forced to choose between these performance attributes and price in terms of user time. This premise is confirmed below when users are required to make choices between levels of quality of search and speed of response. The tendency is to choose quality over speed of response.

Below are the results of the last combination of pairs of attributes: quality of search and speed of response.

Speed of Response	Quality of Search		
	High Relevance	Medium Relevance	Low Relevance
W/in Day	1 (1, 1)	3.49 (2, 4)	4.97 (3, 7)
W/in 3 days	2.97 (2, 4)	4.81 (3, 6)	7.06 (6, 8)
Over 3 days	5.25 (3, 7)	7.19 (6, 8)	9 (9, 9)

The survey results were then used to estimate utility scales for the value and performance attributes. These utility values are given in Tables 19 and 20.

Table 19
Normalized Utilities from Conjoint Analysis
By Performance Attributes for Three Libraries - 1984

(MANUAL SEARCHES)

Performance Attribute	Level	Library One	Library Two	Library Three
Quality of Search	1. not specified	2	8	12
	2. high relevance	37	40	43
	3. medium relevance	16	24	22
	4. low relevance	0	0	0
Speed of Response	1. not specified	0	0	0
	2. within 1 day	32	26	24
	3. between 1-3 days	16	15	5
	4. over 3 days	0	0	0
Price (in Terms of User's Time)	1. not specified	0	4	6
	2. 1/2 hour	30	33	33
	3. 1/2 to 1 hour	14	22	13
	4. 1 to 2 hours	3	0	0

SOURCE: King Research, Inc.

Table 20
Normalized Utilities from Conjoint Analysis
By Performance Attributes for Three Libraries - 1984

(ONLINE SEARCHES)

Performance Attribute	Level	Library One	Library Two	Library Three
Quality of Search	1. not specified	4	4	7
	2. high relevance	39	39	43
	3. medium relevance	20	21	22
	4. low relevance	0	0	0
Speed of Response	1. not specified	0	0	0
	2. within 1 day	31	33	28
	3. between 1-3 days	16	16	16
	4. over 3 days	0	0	0
Price (in Terms of User's Time)	1. not specified	0	0	0
	2. 1/2 hour	29	28	28
	3. 1/2 to 1 hour	16	17	16
	4. 1 to 2 hours	1	4	0

SOURCE: King Research, Inc.

Several interesting results stem from the utilities given in Tables 19 and 20. The factor with the greatest utility and therefore the greatest importance is quality of search. The remaining two factors "price" and speed, have similar utilities about 3/4 as high as quality.

The total utility of a service or a combination of performance attributes can be calculated by adding the appropriate utility associated with the level of the attributes of that service. For example, suppose a manual search service at library One had quality of search at medium relevance, and speed of response at over three days, and a price (in terms of user's time) of 1/2 hour. The total utility would be 46 (16+0+30). Total utilities for other combinations of quality, speed, and "price" can be computed similarly. Indeed, the total utility can be computed for combinations not appearing in last two matrices.

It should be mentioned that the range of utilities covered by Tables 19 and 20 depend on the specific factors and levels included in the questionnaire. If additional factors, or additional levels within one of the factors had been included, the set of utility components would change. For example, if the quality of reproduction had beed included as a third performance attribute, the set of component utilities of Tables 19 and 20 would change. Such changes could affect the relative importance of the factors.

One can also directly convert "price" (value in terms of willingness to pay) into dollars and compare combinations of the quality of timeliness against the value or dollar amount. For example, the utilities for value (i.e., price in terms of user time) is given below for manual searches and online searches. The conversion factor is about $0.90 per utility. Thus, for manual searching the value of one day response and high level of relevance is $59.40. For 2 1/2 days response and medium level of relevance the value is $35.10, and so on. The response curves for the values are shown in Figures 8 and 9. These are for all libraries.

One can see in Figure 8 that users are willing to pay $59 for searches that have high relevance of responses and are delivered in one day. If we lower the quality to medium relevance of responses, the users are willing to pay only $45. If the speed of delivery of these searches is increased to over three days, the users are willing to pay $23 less ($45 minus $22). Generally, users are willing to pay more for online searches than manual searches, except when they are of low quality or slow response times. It is felt that this model provides a valuable tool for decision-making in a library or in designing a search system.

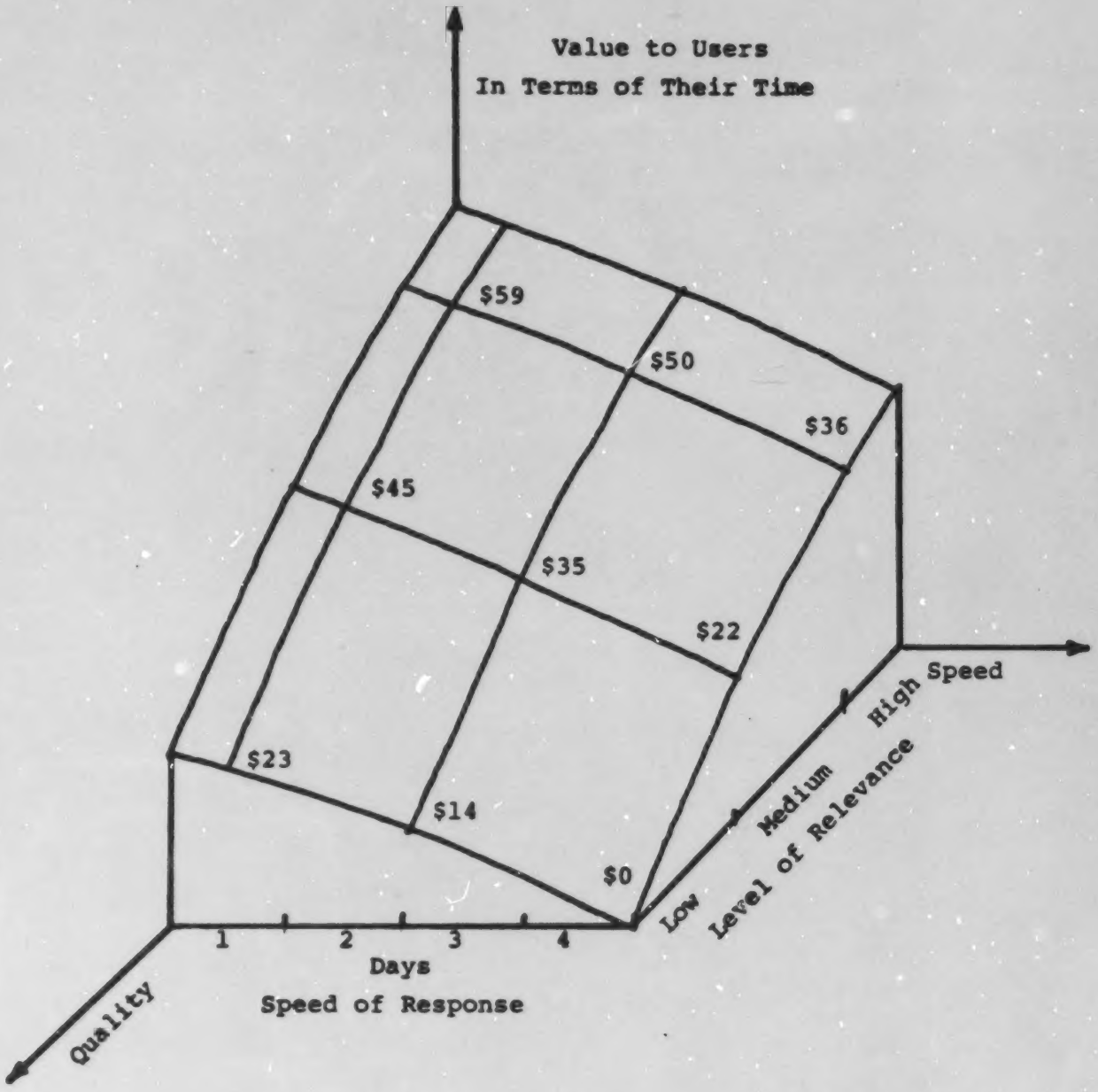

Figure 8: Value of Manual Searches to Relationship of Level of Relevance and Speed of Response

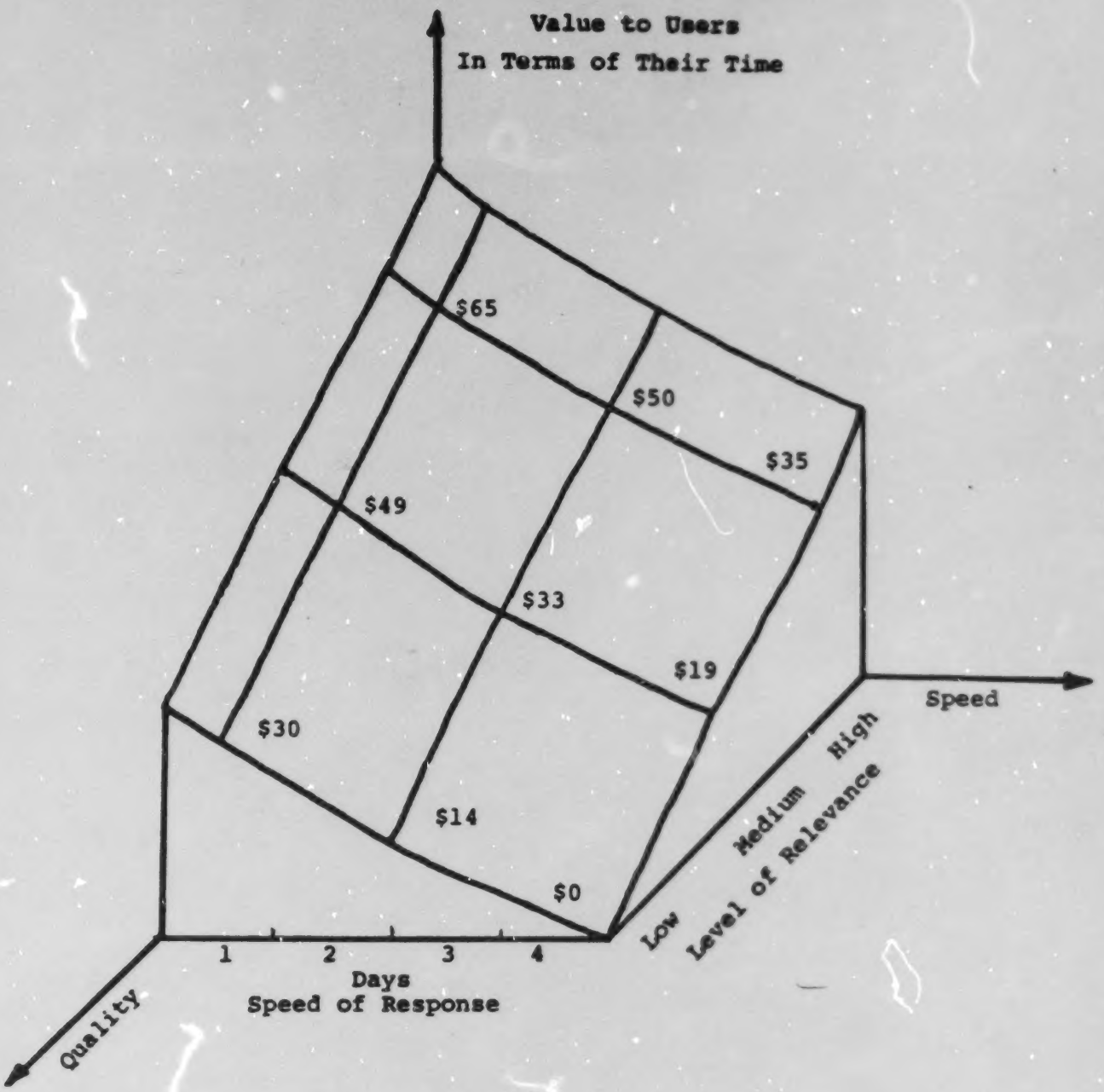

Figure 9: Relationship of Value of Online Searches to Level of Relevance and Speed of Response

APPENDIX A

DETAILED COST ANALYSIS

The current cost of journal reading is summarized in Table A.1 below.

Table A.1
Current Cost of Reading Journal Articles
by Method of Identification and Activity - 1984

Method of Identification / Source of Cost	Number of Readings	Activity: Storage	Identification	Access	Reading	Total Cost ($ million)
Browsing	86,489					
Professionals			$ 5.78		$24.64	$2.631
Other		$3.94		$0.73		0.404
Colleague	18,208					
Professionals			2.28	3.65	24.64	0.557
Other		3.94		0.73		0.087
Cited in Article	50.072					
Professionals			2.28	3.65	24.64	1.531
Other		3.94		0.73		0.234
Printed Index	27,312					
Professionals			2.21	3.65	24.64	0.833
Other		3.94	1.62	0.73		0.172
Online Search	15,932					
Professionals			0.19	3.65	24.64	0.454
Other		3.94	0.49	0.73		0.082
Routed	13,656					
Professionals			4.56	3.65	24.64	0.411
Other		3.94		0.73		0.057

SOURCE: King Research, Inc.

The principal assumptions leading to the results above are as follows:

a. Browsing. It was estimated from the survey that the average time taken to get to a library is 4 minutes. Thus, the total time would be 8 minutes. It is assumed that three articles are read per visit and that it takes about 10 minutes of browsing per article read in this manner. It was estimated from the survey that 29 percent of the articles read in libraries are photo- copied. Then the average cost would be about $0.73 per article read ($0.25 x ten pages x 0.29).

b. Colleague. It is assumed that identification of articles from a colleague would require about 5 minutes and the article copy would be obtained from the library (8-minute trips and photo-copy at $0.73).

c. Cited in Article. No time or cost is allocated to identification of the article since reading an article is accounted for elsewhere. Access is as above.

d. Search of Printed Index. It was estimated from the survey that 38 percent of the manual searches were performed by the users. Amount of time spent searching was determined from the NSF survey. The time and cost of librarian searches was adopted from the EDB value research (p. 66). It was assumed that users also spent 5 minutes in these searches. The users average 5.0 article readings per search, thus costs were divided by this number. Access is the same as above.

e. Online Search. The survey indicated that users performed about 16 percent of the online searches themselves. Their time was derived from the NSF survey and other search costs were found from the EDB study (p. 68). Users averaged 19.3 articles read per search. Access is the same as above.

g. Routed Journals. Here identification time was assumed to be 10 minutes and access time assumed to be 2 minutes.

The reading time was determined from the user surveys.

Table A.2
Alternative Cost of Reading Journal Articles
by Method of Identification and Activity - 1984

Method of Identification / Source of Cost	Activity: Identification ($)	Access ($)	Reading ($)	All Costs ($)	New Readings
Browsing					54,873
Professionals		$5.70	$24.64	$30.34	
Other	$16.44			16.44	
Colleague					14,962
Professionals	2.28	5.93	24.64	32.85	
Other		10.06		10.06	
Cited in Article					41,133
Professionals	2.28	5.93	24.64	32.85	
Other		10.06		10.06	
Printed Index					20,506
Professionals	6.76	5.93	24.64	39.85	
Other	1.62	10.06		11.68	
Online Search					12,559
Professionals	1.56	5.93	24.64	32.13	
Other	0.49	10.06		10.55	
Routed					10,004
Professionals		5.70	24.64	30.34	
Other	16.44			16.44	

SOURCE: King Research, Inc.

Assumptions leading to the above costs are as follows:

a. Browsing. It is estimated from the survey that about 50 percent of the users would use another library if their present library was not available. It was assumed that it would take 15 minutes to get to the alternative library. Costs include 29 percent of these articles being photocopied. It was further assumed that remainder of these readings would come from subscriptions to the journals and that the average readings would be 6 per journal. Identification is the same as that for browsing or routed copy.

b. Colleague. The survey indicated that access to library materials would come from (1) another library (55%) in which use costs would include ordering (10 minutes), postage or telephone ($0.20), receipt processing (3 minutes), and lender costs of $13.23; (2) colleague/author (36%) at approximately the same ordering costs, and lender costs at $5.15; (3) publisher/document delivery (9%) at ordering costs of $0.92 and price at $8.00 (UMI). Identification is the same as the current system.

c. Cited in Article. No identification cost and access the same as colleague.

d. Printed Index. Identification adds the cost of going to a new library to search (30 minutes) for searches done by users, and a delay cost for searches done by intermediaries ($5.66). All other costs are the same as current system. Access same as above.

e. Online Search. Same identification assumptions as above. Access same as above.

g. Routing. Same assumptions as with browsing.

THE VALUE OF
THE NATIONAL ENERGY SOFTWARE CENTER
AND THE
RADIATION SHIELDING INFORMATION CENTER
VOLUME 2

Submitted to:

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VOLUME 2

THE VALUE OF THE NATIONAL ENERGY SOFTWARE CENTER AND THE RADIATION SHIELDING INFORMATION CENTER

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THE VALUE OF THE NATIONAL ENERGY SOFTWARE CENTER AND THE RADIATION SHIELDING INFORMATION CENTER

1.1 Background

In 1982, a study was performed for the U.S. Department of Energy Technical Information Center (now Office of Scientific and Technical Information) to investigate the value of information generated from DOE R&D funding and the contribution that the Energy Data Base and its derivative services and products make to the value of this information. The results of the study demonstrated that energy information has substantial value when considered from the standpoints of amount of use, purposes of use, and value measured by what users are willing to pay for the information and the savings in labor, equipment, etc. derived from use of the information. Furthermore, energy information services and products derived from the Energy Data Base clearly contribute greatly to the value of energy information by making it more accessible and, therefore, more usable.

It was felt that the methods and models employed in the previous studies ought to be refined and an additional investigation made to determine what contribution intermediary information transfer organizations such as libraries and information analysis centers make to the value of information. Also, other factors such as timeliness of primary publishing and distribution and comprehensiveness of the Energy Data Base were considered to be important as well. This further investigation was made under a grant from the National Science Foundation with partial contribution by the Department of Energy, Office of Scientific and Technical Information. This report provides the result of the study of the value of information analysis centers.

Volume 1 gives an analysis of the value of the services provided by libraries. The library study estimated the value of library services (in terms of willingness to pay and savings). It also provided the relationships of the use of library services and factors such as performance attributes (i.e., quality and timeliness of services), distance

to the library, awareness of services and economics of library use. Volume 3 provides an analysis of the value of the timeliness and comprehensiveness of the Energy Data Base.

1.2 Introduction

In looking at information organizations in the value added information chain for energy information, one group studied is involved not so much in the transfer of published information but of computer software and data. The two organizations studied that fall into this category are the National Energy Software Center (NESC) and the Radiation Shielding Information Center (RSIC). Because of the differences in the form of information dealt with, the flow of this information from author to users, and the uses made of software, these two organizations are considered separately. Figure 1 depicts the activities involved in the development and use of computer programs (also called software or code packages) with the involvement of a software center. The initial box indicates that the program is first developed by an individual organization to meet a particular need. Documentation is developed. When the program has been written and tested, it is put to use on a one time or, more frequently, a recurring basis for that purpose. It may also be submitted to a software center. It then goes through some level of review and testing and is announced in catalogs, indexes, newsletters, and other secondary products and services. Other organizations with a need for the same or a similar program can obtain the program and documentation from the software center, modify it as needed, install it on their particular computer, and then apply it, thus shortcutting what can be a very extensive development activity. Critical software center activities in this cycle are the acquisition of programs appropriate for sharing, review and testing of both software and its documentation, development of secondary announcement products, and support to secondary users of the software. A significant difference in the software information chain as compared with published information is the dynamic nature of the program, which is likely to be improved and modified.

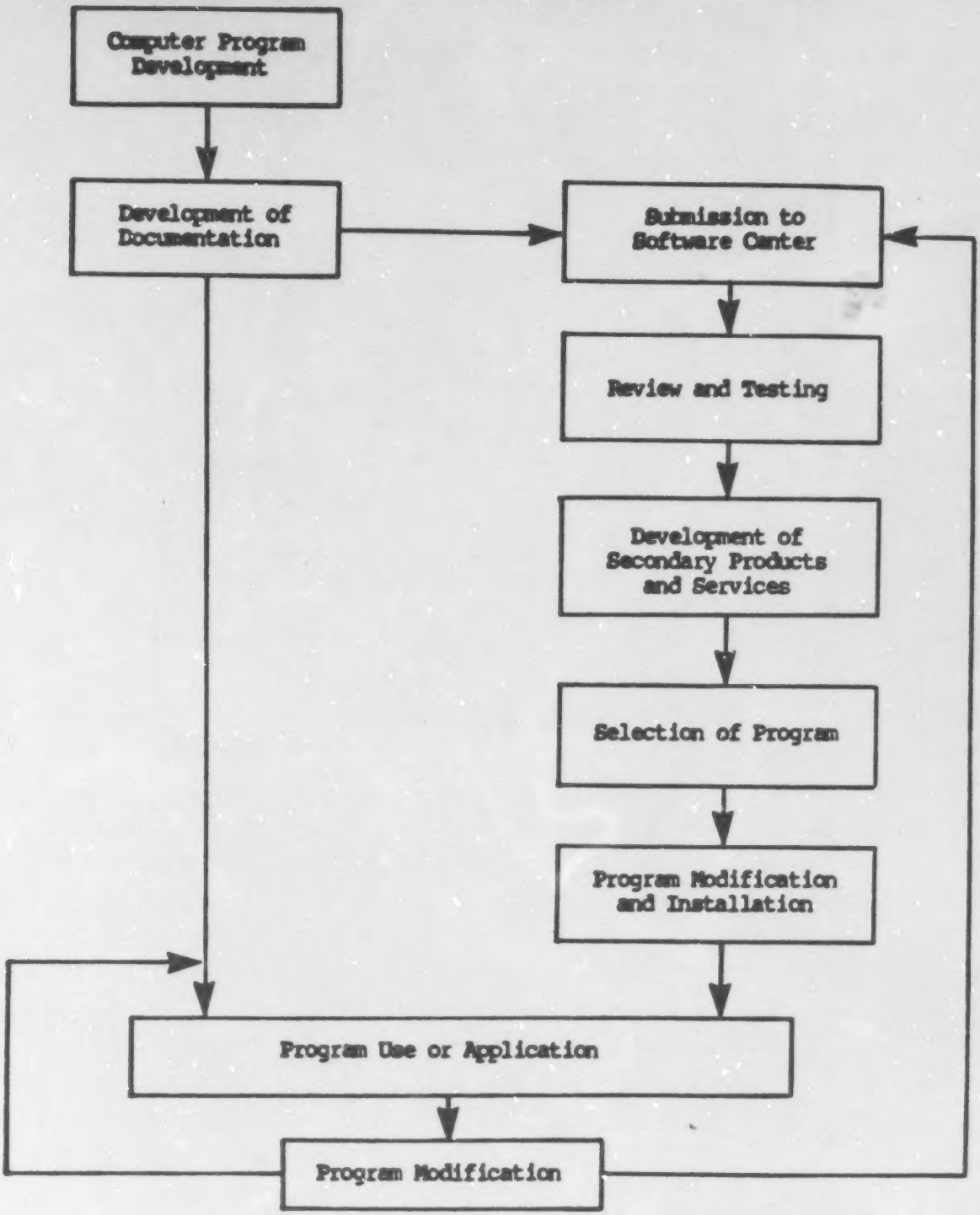

Figure 1. The Software Information Chain

This volume addresses the roles played by the National Energy Software Center and the Radiation Shielding Information Center in the software information chain. Sections below describe the major features of each of the two organizations in turn and discuss the costs associated with the services they provide. Information gathered from users on the value of NESC and RSIC services is also discussed. Finally, results from the two organizations are combined to support the nature of the benefits derived from such services and their potential relationships to productivity.

1.3 The National Energy Software Center

The National Energy Software Center (NESC) is a Department of Energy Software Exchange and Information Center; it is operated by Argonne National Laboratory, under the DOE Technical Information Services program. Software exchange and information center activities for the U.S. Nuclear Regulatory Commission are carried out with support from NRC.

The major objectives of the NESC are:

- To promote the sharing of computer software among agency offices and contractors to eliminate duplication of effort and unnecessary expenditures.
- To facilitate the transfer of computer applications and technology to the information-processing community.
- To arrange the exchange of software with other U.S. and foreign agencies and to assist in the acquisition of nongovernment software for DOE offices and cost-type contractors.

NESC collects, packages, maintains and distributes a library of computer programs, models, systems routines, and data compilations developed by DOE, NRC, and their contractors in carrying out the agencies' research and development activities. NESC checks the library packages to make certain they are complete and runs test cases to make certain they operate as described.

NESC also prepares and distributes (1) abstracts describing the software packages in the NESC collection and (2) summaries of software not included in the collection but often available on an "as is" basis.

NESC will consult with users on their software needs and will help them obtain the software needed. Registered organizations may obtain a copy of any NESC software package they are eligible to receive (distribution of some packages is limited). NESC will also help DOE and its contractors obtain needed software from commercial sources. The NESC maintains an inventory of commercial software and issues the NESC Newsletter, which contains information on software products and services of interest to DOE contractors. Acquisitions of commercial software for DOE use are coordinated by NESC.

NESC also communicates with and arranges for exchanges with other U.S. government software centers and with foreign computer program libraries and is the focal point for DOE participation in the Federal Software Exchange. In addition, NESC distributes software packages from the OECD Nuclear Energy Agency Data Bank to U.S. and Canadian requesters.

The NESC software packages are largely those developed to meet the programmatic needs of the Department of Energy and the Nuclear Regulatory Commission. Computer programs and data compilations arrive at NESC when submitted by agency program divisions in compliance with guidelines and contract requirements, contributed by authors or software development contractors, offered vendor exchange agreements, or solicited by NESC.

A software package provided by NESC contains, insofar as is practicable, all elements required for using the software or for implementing it in a different computer environment. The packages consist basically of computer-media material and printed material. Other products and services of NESC include consultation with users and publication of the following products.

- The NESC Newsletter -- a quarterly publication providing information on software developments by other U.S. government agencies and commercial firms.
- The NESC Bulletin — a bi-monthly presentation of information on NESC activities and recent contributions.
- Compilation of Program Abstracts — a catalog of programs available from NESC.

- NESC Notes — notification of modification or correction to a program.

Information about NESC-provided programs is also provided on the DOE/RECON online retrieval system.

NESC services are provided primarily to registered installations, including DOE laboratories, educational institutions, government bodies, non-profit organizations and commercial entities. Subscription fees for different types of users provide for receipt of publications and for information services. Subscribers are entitled, without further charge, to obtain two software packages per year and additional packages are provided under a primary schedule. In 1983, there were about 200 registered subscribers at NESC.

Information on the users of the products and services of the National Energy Software Center was derived from a small survey conducted in the Spring of 1984. The sample of the survey was a random selection of 25 users from fiscal year 1983; 15 of whom responded to our mail questionnaires. While this sample is quite small, it does give an indication of the behavior, attitude and opinions of NESC users. When available, survey results presented below are supplemented with results from other studies and surveys.

Respondents to the NESC questionnaire were asked about a specific instance of their obtaining a software package from the Center. To help in an understanding of their flow of information, we asked about the ways in which the respondent identified the software package. The most frequent source of information was a colleague or coworker (63%) and the other source mentioned was NESC publications (37%).

Since a major aspect of value derived from use of the software center is the use of that software, respondents were asked if they had installed the software they received at their facility. Seventy-three percent indicated that they had, and another 20 percent were in the process of doing so. Thus, only seven percent did not plan on installing the software. About half the respondents modified the software received to

some extent, generally because of some hardware-specific requirements. On the average, just under 80 hours were spent by those individuals who did make some modifications. Another 70 hours, on the average, was spent installing the software packages at the users' installations. In the course of this installation, about a quarter of the respondents consulted with NESC an average of about two times each.

What resulted from the installation of NESC-supplied software at the user installations? While the ultimate benefits of the specific program to the institution are not known, some indication of value is given in respondents' indications of the number of times that software would be run at that institution. Estimates given by those who had installed or planned to install the software ranged from five to "thousands" and "hundreds daily", averaging out to about once per working day on an annual basis.

As with users of other types of information covered elsewhere in this report, NESC users of software were asked to indicate something about the alternatives to using NESC. The most frequently mentioned alternative was to obtain commercial software (44%), while about a third indicated that they would write a new program or modify an existing one themselves. Other responses given indicated that software might be obtained from another source (17%) or that nothing would be done. Estimates of the time required to generate the software obtained had it not been available ranged from 20 hours to many person years, averaging about 1.5 person years.

To develop an indication of the overall use of NESC services, survey respondents were asked about their level of use within the last years of the following: the NESC Nesletter, the NESC Bulletin, the catalog Compilation of Program Abstracts, NESC listings on the RECON database and NESC consulting services. (Respondents were not asked about NESC's provision of software packages since all were known users of that service.) Results are indicated in Table 1.

Table 1

Awareness and Use of NESC Products and Services

NESC Product or Service	Percent of Respondents Aware of	Using	Average Annual Uses*
NESC Newsletter	60%	47%	1.7
NESC Bulletin	40%	33%	2.4
Compilation of Program Abstracts	53%	47%	1.8
NESC Listings on RECON Database	20%	7%	.3
Consulting Services	20%	—	—

* Average is computed across all users of NESC Services.

SOURCE: NESC User Survey, Spring 1984

As shown, the NESC Newsletter and Compilation of Program Abstracts are used by nearly half of all NESC users. The NESC Bulletin is used by about a third of the respondents, while NESC listings on RECON (a new service), and consulting services were not widely used or known. Generally, most of those aware of an NESC product or service use it. Levels of use of the services, also shown in Table 1, were about 2 uses per user per year of the Bulletin, Newsletter, and Compilation.

Another approach to understanding the value of NESC services to its users is reflected in their rankings of the respective services. Composite rankings by the users surveyed are shown in Table 2, and indicate an assignment of the highest ranking to NESC's primary service, the provision of software packages. Next in ranking are the NESC publications, beginning with the Compilation of Program Abstracts and going on to the NESC Newsletter, Computer Software Summaries, and the NESC Bulletin. As anticipated from the levels of awareness and use, NESC listings on RECON and consulting services were given the lowest rankings.

Table 2

User Rankings of NESC Products and Services

Product or Service	Composite User Ranking
Provision of software packages	1
Compilation of Program Abstracts	2
NESC Newsletter	3
Computer Software Summaries	4
NESC Bulletin	5
NESC listings on RECON database	6
Consulting services	7

SOURCE: NESC User Survey, Spring 1984.

Information was also sought on the demographic characteristics of NESC users. The group was highly educated, with 47 percent holding a Doctoral degree as their highest degree and 40 percent holding a Master's degree. Sixty percent spent the greatest proportion of their time in research and development and the remaining forty percent in management activities. A third of the group have salaries over $55,000, and the median salary is $50,000. Nearly three quarters of the group were funded, at least in part, by the Federal government, with about a third funded by DOE. Other funding agencies mentioned were the Department of Defense, the National Aeronautics and Space Administration, the National Science Foundation, and the Department of Interior.

In addition to looking at user relations to NESC as a software center, this study also addresses the volume of actitivity and associated costs. NESC statistics reflect the activities performed and the levels of use of the various products and services. Table 3 summarizes the NESC level of activity in fiscal year 1983. In the program acquisition, testing and processing area, 160 contributions were received, 148 screened, and 175

Table 3

National Energy Software Center FY1983 Activity

• 355	REQUESTS FOR SOFTWARE OR AUTHORIZATIONS FOR USE FILLED
• 160	SOFTWARE CONTRIBUTIONS RECEIVED; 9 FROM THE NEA DATA BANK
• 148	CONTRIBUTIONS PACKAGED WITH 65 OF THESE TESTED BY EXECUTION OF SAMPLE PROBLEMS
• 97	CONTRIBUTIONS PROCESSED FOR RELEASE ON AN "AS IS" BASIS
• 206	REGISTERED ORGANIZATIONS AS OF SEPTEMBER 30
• 192	ORGANIZATIONS REQUESTED AND RECEIVED NESC SOFTWARE
• 94	NESC NOTES ISSUED DESCRIBING CORRECTIONS, IMPLEMENTATION INFORMATION, OR TRANSMITTAL TAPES, OR ANNOUNCING THE AVAILABILITY OF REPLACEMENT PROGRAMS OR ADDITIONAL MATERIAL
• 3	NESC BULLETINS WRITTEN AND DISTRIBUTED
• 2	SOFTWARE NEWSLETTERS WRITTEN AND DISTRIBUTED

released on a regular or "as is" basis. Entries were prepared for the Compilation of Program Abstracts and Computer Software Summaries. Three Bulletins were written and distributed, as were two Newsletters. There were 206 registered organizations who received publications and software; the number of filled requests for software or authorizations for use was 355.

The costs of NESC activities in fiscal year 1983 were about $820 thousand. In order to address the question of the costs of different products and services, the Center's expenses were divided into five broad categories: program acquisitions and processing, the Bulletin and Newsletter, the Compilation of Program Abstracts and Computer Software Summaries, provision of programs, and other. Included in the other category are such important activities as involvement in the standards process, but for our purposes these were grouped with administrative costs and considered as an overhead.

Developing a rough breakdown of NESC's costs in the different activity categories, total expenditures in 1983 can be seen as falling into the following components:

Program acquisition and processing	$ 510,000
Bulletin and Newsletter	$ 50,000
CPA and CSS	$ 80,000
Provision of programs	$ 180,000
	$ 820,000

1.4 The Radiation Shielding Information Center

The Radiation Shielding Information Center (RSIC) was established in 1962 at Oak Ridge National Laboratory (ORNL) to serve the United States shielding community. It is sponsored by the U.S. Department of Energy, the U.S. Defense Nuclear Agency, and the U.S. Nuclear Regulatory Commission. The center serves on an international basis and consists of scientific personnel who collect, organize, evaluate, and disseminate radiation protection and shielding information related to radiation from reactors, weapons, and accelerators and to radiation occurring in space.

The Center:

- Examines and analyzes radiation protection, radiation transport and shielding information obtained through surveys of pertinent books, journals and reports.
- Examines digital computer codes written for radiation transport and shielding calculations.
- Examines evaluated and processed cross-section data for use in radiation protection, radiation transport, and shielding research.
- Maintains an information retrieval system which contains abstracted and indexed shielding information selected by its analysts. If an adequate abstract is not available with the document, it is prepared by the Center.
- Maintains an archival microfiche file containing copies of the analyzed literature.
- Reviews specific areas of shielding to determine the state of the art.
- Participates in CSEWG activities, gives leadership to shielding and computing standards activities, and organizes seminar-workshops as needed.

RSIC is both a software center and a more generalized information analysis center. As a software center, it obtains and provides code or software packages within its subject scope and also data packages. Code and data packages received are extensively reviewed and evaluated.

In addition to the provision of code and data packages, RSIC provides a number of related products and services, including consultation with users and the following publications:

- the RSIC Newsletter - a monthly information publication discussing new codes and data and other information of interest
- RSIC Computer Code and Data Collections — a catalog of code and data packages
- other RSIC reports — various technical and analytical reports produced by RSIC.

Descriptions of RSIC packages are also available on the DOE/RECON online retrieval system.

Users of RSIC come from all sectors of the radiation shielding and related communities. In 1983, users represented 667 different installations from the U.S. and from over 50 other countries around the world. There are no subscription fees associated with RSIC use.

As with the National Energy Software Center, information about the use of RSIC was obtained from a small survey of users. In this case, the sample was selected from the installations with 20 or more requests in fiscal year 1983. All the 25 individual users surveyed were recipients of the RSIC Newsletter. From RSIC records the requests made by these individuals in 1983 were identified, and then each person was asked about specific instances of use in one or more of the following categories: acquisition of code or data package, consulting or discussions with RSIC staff, and acquisition of a document. Respondents were also asked general questions about their use of and attitude toward RSIC products and services and about their demographic characteristics. The survey was conducted by mail in the Spring of 1984; the overall response was 14 users.

In asking RSIC users about code and data packages they acquired, questioning started with the ways in which the user identified or found out about the package. There was more reliance on printed products by RSIC users than by NESC users, with two-thirds of the RSIC users reporting having identified the package through an RSIC publication. Other methods noted were contact with RSIC staff and a colleague or co-worker, both accounting for 17 percent of the uses each.

As with NESC, nearly all (83 percent) of the recipients of code or data packages had installed or were in the process of installing the package at their facility. Fewer had made modifications, with about a quarter indicating some degree of change made to the code or data package. The level of effort involved in making modifications was about 80 hours per package on the average.

About half, or 56 percent, of the users of packages consulted with RSIC staff in the process of installing the package. The average number of consultations was three. RSIC users spent somewhat less time than NESC users in installing packages, with the average being about 40 hours per package.

Again, one element of the value of a code or data package to the user is the number of times it will be run at their facility. Responses given by RSIC users ranged widely, from five times to daily. On the average, about 120 uses per package were anticipated.

Had the package acquired not been available from RSIC, users indicated, the most likely alternative chosen would have been to write or generate a new code or data package or modify an existing one. This option was indicated by 56 percent of the users. Other alternatives noted were that packages might be obtained from another source (22%) or that nothing would be done (22%). As with NESC, the number of hours estimated for generating a package were it not available ranged widely, but the average was about 1.5 person years.

RSIC users were asked if they would be willing to pay for the package they received, and about two-thirds indicated that they would. The response confirms the value perceived by users.

In addition to their acquisition of code and data packages, RSIC users were also asked about specific instances of use of RSIC for discussions or consultations and for publications. Insufficient data was obtained on publications to analyze, but half of the respondents provided information on discussions they had with RSIC staff. These discussions ranged across a wide variety of topics and were well-appreciated; all the respondents indicated that they had obtained the information they sought. General categories of purposes for the discussions indicated by respondents included background information (57% of respondents), information on methodology (29%), comparison of alternative code or data packages (57%), characteristics of particular code or data packages (71%), and entering a code or data package into RSIC (43%).

Which of the other RSIC products and services are known, and used, and what were the levels of use? These questions were explored with survey respondents, and the results are shown in Table 4. As with NESC, the most recognized and used products are the Center's newsletter and catalog. For both of these, all users reported awareness and 93 percent reported use, with average annual uses of 27 for the RSIC Newsletter and five for the RSIC Computer Code and Data Collections. Users also reported an average of 4.6 uses of RSIC reports and 3.0 uses of RSIC's consulting services. Only a small percentage of users had yet made use of the RECON database to access RSIC listings.

Table 4

Awareness and Use of RSIC Products and Services

RSIC Product or Service	Percent of Respondents Aware of	Using	Average Annual Uses*
RSIC Newsletter	100%	93%	27
RSIC Reports	71%	57%	4.6
RSCI Computer Code and Data Collections	100%	93%	5.0
RSIC Listings on RECON Database	57%	7%	—
Consulting Services	86%	64%	3.0

* Average is computed across all users of RSIC Services.

SOURCE: RSIC User Survey, Spring 1984.

To provide another perspective, survey respondents were asked to rank all of the RSIC products and services on the basis of their usefulness. As shown in Table 5, the highest ranking was given to the provision of code packages, followed by package documentation and the provision of data packages. The newsletter and catalog publications were ranked next in usefulness, followed by RSIC consulting services. Lowest on the ranked list were RSIC reports, abstracts, publications, and the relatively new RECON listings. It is interesting to note that, with one exception, the RSIC user rankings closely mirror those of NESC users — first, the packages themselves, then the newsletter and catalog, and finally other publications. The exception is consulting services, which RSIC users rank more highly than do NESC users. Results of ranking by RSIC users are similar to those obtained in a much larger survey of the group conducted in 1977 (3).

Table 5

User Rankings of RSIC Products and Services

Product or Service	Composite User Ranking
Provision of code packages	1
Documentation of packages	2
Provision of data packages	3
RSIC Newsletter	4
RSIC Computer Code and Data Collections	5
Consulting Services	6
RSIC reports	7
RSIC abstract publications	8
RSIC listings on RECON database	9

SOURCE: RSIC User Survey Spring 1984

Respondents to the RSIC questionnaire were asked to indicate basic demographic characteristics, allowing us to develop a user profile. Most respondents, 71 percent, were involved in research and development with the remainder spending the largest proportion of their time in management or operations (14% each). Half the respondents had Master's degrees; 36 percent had Doctorates, and the remaining 14 percent had Bachelor's degrees only. A wide salary range was reported with a median salary of $35,000. Users come both from projects funded by the Federal goverment (57%) and from other areas; the Department of Energy was the primary agency when Federal funding was indicated.

As with NESC, the study of RSIC also involved the consideration of the volume of activity and associated costs. The level of RSIC activity in fiscal year 1983 is reflected in Table 6. As indicated, 172 packages in total were contributed including new programs and data libraries, new hardware versions, and updates and error corrections. Seventy-one packages were processed for announcement and distribution. The Newsletter was developed and distributed, and in the use area, a total of 3,213 letters and calls requesting 9,857 products and services were received. Among the products and services provided were 1,050 code or data packages, 150 additional documents, and 8,570 responses to inquiries.

The costs of RSIC activities in fiscal year 1983 were about $900,000. In order to look at the product and service costs specifically, total expenditures were subdivided into: package acquisition and processing, publications and provision of packages, consultation, research and development, and administrative and other activities. Considering the expense of administrative and other activities as overhead, the rough breakdown of RSIC costs derived was as follows:

Package acquisition and processing	$ 500,000
Publications and provision of programs	$ 170,000
Consultation	$ 110,000
Research and Development	$ 120,000
	$ 900,000

Table 6

RSIC Activity Statistics (Fiscal Year 1983)

TECHNOLOGY CONTRIBUTED:

- 89 New computer programs and data libraries
- 18 New hardware versions to extend existing code or data packages
- 22 Updates for error corrections discovered in using existing code/data packages
- 43 Updates to existing code/data packages

TECHNOLOGY PROCESSED:

- 26 New code packages
- 5 New data packages
- 7 Updates to include conversions of RSIC code packages to run on other hardware
- 9 Newly frozen computer program versions including improvements made over that originally packaged
- 5 Updates to data packages
- 19 Updates to code packages
- 71 Total packages processed

PUBLICATIONS:

- Monthly Newsletter to a peak of 1664 people

DISSEMINATION:

- 3213 Letters and calls requesting 9,857 products and services
- 1050 Code/data packages provided
- 150 Additional documents provided
- 8570 Responses to inquiries for information

1.5 The Value of Software Center Products and Services

As has been indicated, both NESC and RSIC provide a considerable range of products and services related to software and data packages. Their publications both provide information about the packages and serve additional purposes such as to inform subscribers about commercial software. Consultation services provided, especially by RSIC, are not only associated with the provision of packages but may also be concerned with data, techniques, and programming in general. Both RSIC and NESC, in addition to the acquisition and distribution of code packages, are also involved in such professional activities as standards development.

The two organizations, NESC and RSIC, have a general mission in common but are otherwise fairly different in their operations. Subject scope, as indicated earlier, is different, with NESC having a broader scope. The level of processing also varies, with NESC processing some contributions for release on an "as is" basis and RSIC, in general, doing more elaborate testing. Depending primarily on their user community, the two organizations have also developed different types of supporting services.

The major concern in this section of the report is with NESC and RSIC as providers of software packages, and with the value associated with that service. In that regard, we view the two groups together and consider, in turn, their costs of operation, and volume of service provided as indications of the value derived from these services.

In fiscal year 1983, the total expenditures of NESC and RSIC were $1.7 million. Of these costs, $1.0 million was spent on package acquisition and processing and $700 thousand on distribution and related services. Between the two organizations, with their different levels of processing, about 250 packages were processed and 1400 packages were provided to users. One set of unit costs that can be derived from these numbers is $6,800 per package input and $500 per package provision. More properly, the total cost of providing one software package, on the average and including acquisition and related service costs, is about $1,200.

There are, of course, other costs involved in the provision and use of energy software. We do not know, for example, what the original costs of developing the software in NESC and RSIC were. In terms used elsewhere in Volume 1, these might be considered authorship costs. Other costs in the dissemination chain would include the cost of submitting the software to a Center, the costs of identifying the Center as a source, and the costs of modifying and installing a package once it is received. Based on user estimates obtained in the user surveys, modification and installation activities for all packages received from the two Centers averaged about 75 hours or $2,700. Adding this to NESC and RSIC costs for their services, we estimate a total cost of $3,900 per installation of an energy software package. The cost to the user on the average is the $2,700 labor cost incurrred plus an approximate $700 share of the NESC subscription fee paid. This yields a total effective price of $3,400 per use. That is, the users indicate they are willing to pay $3,400 per installed package (1,160) or $39 million in total.

To address the value of the NESC and RSIC-provided software services, we can first review the costs of obtaining the same packages from other sources. The most likely alternative source indicated by respondents was in-house development of the program; this was estimated on the average to require about 1.5 person years of effort or nearly $68,000 in labor. This suggests that, on the average, an investment of $3,900 in using one of the software centers leads to a savings of $64,000. Applied across the 1160 packages provided and installed, this suggests a total savings of about $74 million.

The value of the services is computed by determining what would happen if the services were not available. The current total cost of acquiring the software packages is $4.8 million (1,400 x $3,400). If it costs $68,100 to prepare these packages in-house, the users could only prepare 70 software packages with the $4.8 million now being spent. Thus, 1,090 packages would be lost (1,160 minus 70). The value in terms of willingness to pay of these lost software packages is $3.7 million. The value in terms of savings to users of these services is $74 million. The investment in these services seems clearly worthwhile.

Another indication of value would reflect the value of the use made of the software package. While this was not explained in the user survey, it is known that the software packages provided by NESC and RSIC are used, on the average, about 150 times. This suggests, at least, that there is considerable value derived from them.

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THE EFFECT OF TIMELINESS AND COMPREHENSIVENESS ON VALUE
VOLUME 3

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VOLUME 3

THE EFFECTS OF TIMELINESS AND COMPREHENSIVENESS ON VALUE

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SECTION 1
INTRODUCTION

1.1 Background

In 1982 a study was performed for the U.S. Department of Energy Technical Information Center (now Office of Scientific and Technical Information) to investigate the value of information generated from DOE R&D funding and the contribution that the Energy Data Base and its derivative services and products make to the value of this information. The results of the study demonstrated that energy information has substantial value when considered from the standpoints of amount of use, purposes of use, and value measured by what users are willing to pay for the information and the savings in labor, equipment, etc. derived from use of the information. Furthermore, energy information services and products derived from the Energy Data Base clearly contribute greatly to the value of energy information by making it more accessible and, therefore, more usable.

It was felt that the methods and models employed in the previous studies ought to be refined and an additional investigation made to determine what contribution intermediary information transfer organizations such as libraries and information analysis centers make to the value of information. Also, other factors such as timeliness of primary publishing and distribution and comprehensiveness of the Energy Data Base were considered to be important as well. This further investigation was made under a grant from the National Science Foundation with partial contribution by the Department of Energy, Office of Scientific and Technical Information. This volume provides the result of the study of the effect that timeliness and comprehensiveness have on the value of information.

Generally, we looked at timeliness from the standpoint of the duration of time from information generation to publication of articles and technical reports and document delivery time (i.e., time from determination of information need to its delivery). Timeliness of bibliographic publication and speed of response in online and manual searching performed by reference librarians was also addressed. In effect, it was determined

that delays in any of these processes can result in readings or uses being lost and such losses in turn reducing the value of the information; where value is measured in terms of what end-users are willing to pay for the information and the dollar savings that result from having read and used the information. This analysis is reported in Section 2.

The question concerning the value of non-US materials was also investigated. This is done by determining the extent of use of non-US materials, determining substitute means of getting these materials, establishing the readings that would be lost under a given budget, and estimating the values (i.e., willingness to pay and savings) that these lost readings represent. Analysis is performed from surveys of the scientists and engineers from nine fields of science and special surveys of DOE funded scientists and engineers. Results are presented in Section 3.

A special kind of analysis was performed on a sample of searches which were conducted for DOE funded scientists and engineers. The purpose of the analysis was to get some indication of use of non-US materials from the search outputs and to evaluate the use of "cross-cutting" research by DOE-funded scientists and engineers. This was done by comparing the subject categories of online searches that were performed by DOE funded researchers against the subject categorization of the research project for which the search was being performed. We also determined the relevance of search response to the research project as well as to general interest of the researcher. Results of this investigation are discussed in Section 4.

In addition to this volume there are two other volumes. Volume 1 is a report on a study of "The Value of Libraries as Intermediary Information Services". This study attempted to measure the value of library services (in terms of willingness to pay and savings). It also provided evidence as to factors that contribute to the extent of use of library services. Such factors include library performance attributes (i.e., quality and timeliness), distance to the library, awareness of services and economics of library use. Finally, a study of Information Analysis Centers as intermediary information services was done. Its report is Volume 2, "The Value of the National Energy Software Center and the Radiation Shielding Information Center."

1.2 Study Methods

For this study, data collected from three surveys were used:

(1) A survey of the population of scientists and engineers from nine fields of science was conducted as part of a study being performed for the National Science Foundation (Statistical Indicators of Scientific and Technical Communication). This survey involves estimating the extent of authorship of journal articles, journal reading, journal subscriptions, technical report reading, library use, numeric data base searching and bibliographic data base searching. Demographic information identifies scientists and engineers who are funded by DOE.

(2) A survey of the professionals employed at Rocky Flats, Rockwell and ORNL was also conducted. This general information usage survey obtained information about general reading, library use, awareness of services and satisfaction with services. It is noted that this survey included managers, administrators and operational professionals as well as scientists and engineers engaged in R&D.

(3) In addition, four surveys were conducted at the three library locations to determine detailed information about recent uses of specific library materials and services: online searches, manual reference searches, journal articles and technical reports. Data collected included sources of services, value of reading, purposes of use, other value related information and, for the two types of searches, conjoint measurement data.

The survey of scientists and engineers actually was done in two parts. The first part obtained information about journal article authorship, reading (i.e., amount, means of identification and access, purpose of reading and value derived from reading), and journal subscriptions. The second part concentrated on technical report reading, library use, and online searching from numeric and bibliographic databases. Samples for both parts were chosen randomly from lists of scientists and engineers provided by professional societies. The first part involved a mail-out of 1,958 questionnaires, of which 1,252 responded (64 percent response rate). Of these 588 of the scientists and engineers indicated they were not involved, thus yielding 664 questionnaires that were analyzed. The second part had a mail-out of 1,017 questionnaires of which 467 responses were received and 195 were analyzed. The second survey involved DOE funded professionals (scientists and engineers and others) who work at Rocky Flats, Rockwell Energy Systems Group and Oak Ridge National Laboratories.

The professionals were randomly chosen from lists provided by the organizations mentioned above. A total of 200 questionnaires were distributed and 137 received (69 percent response rate). To achieve this level of response the questionnaires were distributed by the libraries (or KRI) to a random sample of professionals who work at the three locations. Some data were collected by telephone follow-up in order to achieve desired response rates. The completed questionnaires were returned to KRI by the respondents by a self-addressed envelope in order to ensure confidentiality.

The last set of surveys involved a total of 143 questionnaires that were distributed to recent library service users (41 article readers, 35 technical report readers, 38 online search users, and 29 manual reference search users). The following number of questionnaires were returned: 30 article readers, 22 technical report readers, 30 online search users, and 9 manual reference search users. The overall response rate was 91 percent.

SECTION 2

THE RELATIONSHIP OF TIMELINESS TO VALUE OF INFORMATION

2.1 Background

In this section we address the question of how important timeliness is to the value of information. There are several aspects to timeliness including (1) the timeliness of publication; that is, the duration of time between generation of information to the date it is published; (2) the timeliness of document delivery, that is, the duration of time between the date a need for information arises and the date an article or technical report is delivered; (3) timeliness with which the documents are announced in bibliographic services, and (4) timeliness of delivery of bibliographic search results. Presumably, delays in any of these activities can result in needed information not being available and therefore, not used, which reduces the value of the information. Thus, reducing the duration of the activities has the potential for increasing the value of the information. The thrust of this investigation is to determine the extent to which information is needed and the value that is lost because it is not available when needed.

Information, whether found in books, journal articles or technical reports, is read and used for many purposes including research, education of oneself, education of others, and management. Sometimes reading and use of the information can take place any time during a wide span of time without any appreciable effect on its value. On the other hand, sometimes information must be read and used consequent to other events or it loses much of its value. For example, data that can replace an experiment must be known prior to the experiment for it to be of value. Knowledge of an environmental regulation must be known prior to an experiment involving toxic substances or construction of a nuclear site. Finally, there are instances in which information has to be read and used within a very short period of time or it totally loses its value. For example, information used in preparing a proposal must be used prior to the proposal's submittal date or it loses its value, or at least the value derived for that purpose.

Evidence from previous studies suggests that much of the reading of journal articles is for self-education, keeping aware of what is happening in the field and satisfying one's curiosity. In these instances, timeliness is not critical. However, there are times when information from journal articles is needed fast (i.e., within a day). Unless the scientist has the article or can get it from a co-worker or the library, the opportunity to read the article in time may be lost. Currently, there is little chance for getting a copy quickly by interlibrary loan or document delivery service, although services such as overnight delivery and the UMI Article Clearinghouse are improving the situation. There seems to be less casual reading of technical reports than journal articles because they are less readily available (i.e., journal issues are widely distributed) and the effort is greater in getting and reading the technical reports. For this reason, timeliness may be a greater factor, particularly in timeliness of document delivery. Finally, timeliness of identification through bibliographic products and services can also be an important factor in the use and value of information found in both journal articles and technical reports.

2.2 Effect of Publishing Delay on Value of Information

There are three factors that one must consider in determining the effect of publishing delays on value of information. The first factor is the delay time between research discovery or project results and the time in which it is published in technical reports, journals and/or books. The second factor deals with the number of readings that would have otherwise occurred during the period of time in which the delay took place. The third factor is the value of these readings in terms of users' willingness to pay for the information and by the savings that are incurred by users as a result of having read the publications. In this analysis we concentrate primarily on readings of technical reports and journal articles. The reason for not including books is that they are read relatively infrequently and the information found in them is rarely as current as that found in technical reports and journal articles.

An indication of what might be read if publications are provided earlier is the distribution of reading over time as shown in Table 1 below.

Table 1

Age of Technical Reports and Journal Articles Read
by Scientists and Engineers - 1984

(%)

Year Published	Technical Report Readings*	Journal Article Readings**
1984***	51%	71%
1983	23	12
1982	9	4
1980-81	9	4
1975-79	3	5
1970-74	3	2
< 1970	2	2
Average Age (Years)	1.4	1.3

*** The survey was taken in May 1984 so responses in 1984 reflect only four months.

Source: King Research, Inc. - Survey of Scientists and Engineers (n^{*}=195, n^{**}=664)

The survey was conducted in May, 1984 so that readings of publications published in 1984 represent current reading; in fact, much of the journal article readings occur as a result of browsing current journal issues. The average age of technical reports and journal articles read is nearly the same. However, the shape of the distribution of age is somewhat different in that 71 percent of the articles read are less than four months old, compared to 51 percent for technical reports. It is noted that many technical reports read are internal reports (i.e., reports prepared within the scientist's organization). Scientists and engineers funded by DOE indicated that 28 percent of their technical report readings came from materials published in the past four months. Thus, it appears that DOE funded scientists and engineers have a better means of getting current technical report publications than scientists and engineers generally.

It is not known exactly what the publication delays are for technical reports. However, evidence from the National Technical Information Service and elsewhere suggests that it takes about three to four months for typical technical reports prepared under government contract to be formally published by the sponsoring agency. Below we give some indication of the amount of reading, usefulness and value of reading that is lost during this lapse of time. As stated earlier, it is felt that most technical report reading is in response to specific needs, reflecting research (or other events) that involves information needs occurring over relatively brief, but specific periods of time. That is, there is probably far less serendipitous finding of valuable information in technical report reading than in journal article reading. This conjecture is reflected in the fact that only about one-fourth of the journal article readings yield savings as a consequence of the readings, whereas across all technical report readings, this proportion is found to be 41 percent (68% for DOE funded scientists and engineers).

Clearly, some value is lost for publishing delays for both technical reports and journal articles. These values are summarized in Table 2 below.

Table 2

Value Lost Due to Publishing Delays for
Technical Reports and Journal Articles - 1984

Type of Material	Value Lost	
	Willingness to Pay	Savings in Labor and Equipment
Technical Reports	$1.5 million	$10 million
Journal Articles	$3.1 million	$33 million

SOURCE: King Research, Inc.

Even though these figures are calculated based on some rough assumptions, the orders of magnitude indicate that publishing delays warrant investigation. The assumptions and methods of calculating values lost due to publishing delays are discussed below.

There are several assumptions that went into the estimates of value lost due to publication delays of technical reports. These assumptions and their effects on lost readings are summarized in Table 3 below. Note that there is a proportion of reading involved with each assumption. This proportion is multiplied against the remaining readings to determine how many remain after the assumption is made.

Table 3

Assumptions Used to Calculate the Number of Technical Report Readings Lost Due to Publication Delay

Assumption	Proportion of Readings Involved	Number of Readings Left
1. Some technical reports would have been useful if they had been published earlier	.27	1,782,000
2. Recently read technical reports are more likely to be involved	.70	1,247,400
3. Information in some of these technical reports is unique (i.e., readers are not aware of other sources of the specific information or equally useful information	.40	498,960
4. Reader already knew about the research that was reported, therefore could have gotten the information from the author (65%)	.35	174,636
5. Publication delay is four months over a four-year period in which information could have been useful	.083	14,495

Scientists and engineers were asked several questions concerning the last technical report they had read (i.e., they reported on a "critical incidence"). One question concerning this technical report was whether the information found in the report would have been useful in the course of their research (or teaching) if it had been published earlier. Responses to this question indicated that 27 percent of the read technical reports would have been useful, if they had been published earlier. It was estimated in 1981 that there were about 6.6 million readings of technical reports by DOE funded scientists and engineers. Thus, if 27 percent of these would have been useful, if published earlier, there would have been 1,782,000 such readings.* Secondly, it is assumed that such lost readings from publishing delays would be more significant from recently published technical reports (i.e., published in 1984). About 70 percent of these technical reports fall into this category. Thus, the uses that would have been made from recently published technical reports are 1,247,400 readings.

The readers were also asked whether the information obtained in the read technical report, or equally useful information, could have been obtained elsewhere. It is assumed that, if the information was not unique, it could have been obtained elsewhere, even if the technical report was published earlier. About 40 percent of the technical reports (published in the past four months and which were indicated to have some use if published earlier) were indicated to have unique information.** Thus, the remaining readings with the above characteristics would be 498,960 readings. Also, in some instances, the readers already knew about the research reported in the technical reports. If they did, we assumed that the reader could have gone to the author to get the information even if the technical report had been published earlier. It was found that 35 percent of the technical reports had this characteristic, so that the number of readings that would have happened if the technical report had been published earlier

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* Note the four significant places (1,782) are maintained in the estimate merely to help clarify the example. Clearly, such degree of accuracy from a survey is spurious.

** Note that, if one does not limit the calculations to recently published technical reports, this proportion would be 38 percent.

is 174,636. Unfortunately, we did not determine when, prior to publication, the technical report would have been used. We assumed that it would have been used sometime between the publication date and four years prior to that. If these uses were evenly distributed over the four years, only 8.3 percent of these readings would be lost due to a four-month publishing delay (4-48). Thus, the remaining 14,495 readings represent those that would be lost due to publishing delay, under all the assumptions made above. The average value of technical report readings is $102 in terms of what users are willing to pay for the information and $706 in terms of the savings that are derived as a result of having read the technical reports. Thus, the total values for the 14,495 readings lost would be about $1.5 million for willingness to pay value lost and $10 million for savings value lost.

For estimating value of publishing journal articles earlier, we make a distinction between reading of recently published articles (i.e., less than four months) and the remaining readings. In 1981/82 there were estimated to be 7.1 million readings of journal articles by DOE funded scientists and engineers.

We do not have data corresponding to the usefulness of the information in the article if it had been published earlier. However, if we assume similar needs to that observed with technical reports, a rough estimate can be derived. First, it is assumed that 19 percent of the recently read articles (less than four months old) would be more useful if published earlier. These, and the other assumptions, are given in Table 4.

If we apply the assumptions above to these readings, about 19 percent of the readings would be from recently published articles and useful prior to their current publication (1,341,900). Of these, 60 percent of these readings involve unique information and information about research that was not known about before. Thus, about 805,140 of the readings would be useful and also be unique. About 40 percent of the read journal articles had research that was not known about before, which is the proportion used to compute the lost readings (322,056). Furthermore, with a 12.9 month publishing delay, the probability over a four-year period that

Table 4

Assumptions Used to Calculate the Number of Journal Article Readings Lost Due to Publication Delay

Assumption	Proportion of Readings Involved	Number of Readings Left
1. Some journal articles would have been useful if they had been published earlier	.27	1,917,000
2. Recently read journal articles are more likely to be involved	.70	1,341,900
3. Information in some of these journal articles is unique (i.e., readers are not aware of other sources of the specific information or equally useful information	.60	805,140
4. Reader already knew about the research that was reported, therefore could have gotten the information from the author (65%)	.40	322,056
5. Publication delay is 12.9 months over a four-year period in which information could have been useful	.27	57,970

readings would be lost due to the publication delay is about 0.27. Thus, the total journal article readings that might be read and savings value derived, if published earlier, is estimated to be about 86,955. The willingness to pay and savings value for reading journal articles are $36 and $385 respectively, so that the total values are about $3.1 million and $33 million respectively.

There are some interesting aspects of the publishing delays and the characteristics of the technical reports and articles that are discussed below. This information might also be used to form different assumptions for calculating number of readings lost due to publishing delays.

As mentioned above the average delay in publishing journal articles is about 12.9 months from the time an article is submitted for publication.

The delay in publishing journal articles appears to be increasing, based on surveys conducted in 1977 and repeated in 1984. Results of these surveys are given in Table 5 below.

Table 5

Elapsed Time Between Article Manuscript Submission and Publication by Field of Science - 1977 and 1984 (Months)

Field of Science	Elapsed Time Between Submission and Publication 1977	1984
Physical Sciences	8.0 months	8.9 months
Mathematics	20.5	17.0
Computer Science	10.6	12.1
Environmental Science	14.4	17.2
Engineering	9.0	9.9
Life Sciences	11.1	12.7
Psychology	12.1	15.1
Social Sciences	10.3	13.1
Other Sciences	5.8	8.3
Total	10.3 months	12.9 months

Source: King Research, Inc. - Survey of Scientists and Engineers (1977 n=600.1984 n=213)

It is noted that the publishing delay in 1984 is greater than that in 1977 in every field of science except mathematics.

Scientists and engineers were asked whether they knew about the research reported or discussed in the article they read prior to reading about it. Not surprisingly, about 40 precent of the incidences in which recent publications (published less than four months ago) were read involved research that was not new. However, up to a point, as the publications get older, the scientists and engineers are more likely to know about the research. Then they begin to be less likely to know about

the research. This may be because some scientists recently entered the field and were not aware of the research or their memories may have lapsed. The results of knowledge of the research are given below in Table 6 below.

Table 6

Proportion of Readings in Which Scientists and Engineers Knew About the Research Reported in Journal Articles by Year of Publication - May 1984

(%)

	Year Article Was Published						
	1984	1983	1982	1980-81	1975-79	1970-74	< 1970
Knew About Research	40	46	74	72	63	58	29
Did Not Know	60	54	26	28	37	42	72
Observations (n)	421	79	23	29	32	12	14

SOURCE: King Research, Inc. - Survey of Scientists and Engineers (n=664)

Analogous results are given for technical reports in Table 7 below.

Table 7

Proportion of Readings in Which Scientists and Engineers Knew About the Research Reported in Technical Reports by Year of Publication - May 1984

(%)

	Year Article Was Published						
	1984	1983	1982	1980-81	1975-79	1970-74	< 1970
Knew About Research	65	67	70	50	75	75	33
Did Not Know	35	37	30	50	25	25	67
Observations (n)	65	30	10	12	4	4	3

SOURCE: King Research, Inc. - Survey of Scientists and Engineers (n=195)

The results show that knowledge of the research reported seems to be greater over time (although sample size may be too small to say for sure). The higher knowledge throughout the ages of the publication for technical reports versus journal articles supports the notion that more serendipitous identification comes from journal articles.

The scientists and engineers were also asked whether the information obtained from the article read (or equally useful information) could be obtained elsewhere. Most of the people who indicated that the information could be obtained elsewhere (e.g., from the author) also indicated a knowledge of the research reported. The publication age pattern of reading of non-unique information found in articles followed that of the knowledge of the research in Table 6. Comparisons are given in Table 8 below. Both patterns begin at 40 percent in 1984, peak in 1982 and end at 29 percent and 20 percent, respectively.

Table 8
Proportion of Reading in Which Scientists and Engineers Knew About the Research Reported in Journal Articles and Felt They Could Get the Information Elsewhere by Year of Publication - May 1984

	Year Article Was Published						
	1984	1983	1982	1980-81	1975-79	1970-74	< 1970
Knew About Research	40	46	74	72	63	58	29
Could Get Information Elsewhere	40	44	53	39	36	27	20
Observations	334	59	19	23	28	11	10

SOURCE: King Research, Inc. - Survey of Scientists and Engineers (n=664)

Results for technical reports are given in Table 9 below.

Table 9

Proportion of Reading in Which Scientists and Engineers Knew About the Research Reported in Technical Reports and Felt They Could Get the Information Elsewhere by Year of Publication - May 1984

	Year Article Was Published						
	1984	1983	1982	1980-81	1975-79	1970-74	< 1970
Knew About Research	65	67	70	50	75	75	33
Could Get Information Elsewhere	45	48	44	30	25	50	100
Observations (n)	55	27	9	10	4	2	1

SOURCE: King Research, Inc. - Survey of Scientists and Engineers (n=195)

2.3 Effect of Delays in Distributing Document Copies on Value of Information

We first looked at the speed with which documents were obtained following the need for (or interest in) them. Results of the speed of delivery of technical reports is as follows:

Speed of Delivery	Proportion of Readings (%)
Immediately	17
Within one day	9
In two days	26
In three to five days	30
In two weeks	9
Over two weeks	13

Some of the technical reports were obtained immediately because they were read from routed copies or while browsing through the shelves or from microform copies of the technical reports.

The scientists and engineers were also asked to indicate the required amount of time (in terms of greatest value) to get the technical reports. Here we find that about one-third of the document deliveries were made at the required amount of time, 28 percent were obtained faster than required, and 39 percent slower than required. In nearly all instances in which the technical reports were obtained after they were required, it was indicated that they were needed very fast (within minutes or hours). They actually got them in one or two days (about 20%), three to five days (about 40%) or over one week (about 40%). It is in these instances, that some value is lost. Of the readings in which some value is lost, about 60 percent of the reports apparently were ordered by the library. Of those ordered by the library, (30% of all readings) about 43 percent were needed within one day. Thus, about 13 percent of all the technical report readings could potentially save value if they could be delivered faster to the library.

Another way to look at speed of delivery is how much use would be lost if document delivery was delayed over one week of the actual delivery. Here it is found that about 12 percent of the technical report readings would be less useful and eight percent of these would not be useful at all. If we apply the eight percent to the figures above as an indication of value that would be lost, the total readings of technical reports in which value would be lost due to late delivery would be about 16,000 readings (.13 x .08 x .23 x 5.6 million). Value in terms of willingness to pay of the lost readings would come to about $1.6 million. Savings value of these readings would be about $11 million. Again, even recognizing the "soft" nature of these estimates, speedy delivery, when needed, should yield substantial value. The same holds true with delivery of journal article separates as well.

Copies of journal articles are more accessible, because individuals and libraries subscribe to journals in anticipation of their use based on past experience with the journals. Generally, individuals do not subscribe to journals unless they frequently read them. Otherwise, they rely on libraries to provide them with copies in which to read. It is also found that it is less expensive to borrow (i.e., get a photocopy) article copies from another library or order one from a document delivery service than to

subscribe to a journal if the number of readings of the journal falls below the accepted range of ten to 20 readings (depending on price). Thus, libraries can provide a useful service to individuals by ordering copies of articles they do not have. About 11 percent of the readings involve such orders of separate copies of articles. We have estimated that 28 percent of these orders require getting the article copies within a day. Thus, about three percent of the readings involve "rush" orders. If, as above, eight percent of these readings would lose their value if not delivered rapidly, the total savings value lost would be about $6.6 million on the 17,000 such readings. Readers indicated that they would be willing to pay an additional $7 per reading on the average for the 213,000 readings in which they require "rush" deliveries, so that the total value they would be willing to pay for these is about $2.9 million ($43 x 213,000).

2.4 The Effect of Delays in Publishing Bibliographic Information on the Value of Information

There are a number of ways that technical reports and journal articles are identified. Two of these ways involve bibliographic services and products such as the Energy Research Abstracts (ERA), a printed publication of abstracts and indexes, and RECON, an online bibliographic database. It takes some time to produce bibliographic databases and the services and products from these databases. A question arises as to the value of information that would be gained, if the databases and their derivative products would be produced and made available faster. This question is answered in part by the amount of reading that occurs from the bibliographic publications and search services. It also depends on the age of materials read from these services. These factors are discussed below.

A survey of Department of Energy funded scientists and engineers* showed that the majority of readings of technical reports are identified through distribution methods such as routed copies or accession lists (52%). Many of the technical reports are also identified via referrals

* The initial survey reported in "Value of the Energy Data Base," King Research, Inc., March 1982.

from the readers' colleagues (24%), as well as by their citation in other technical reports or journal articles (8%). It was estimated that this population of scientists and engineers also frequently identified read technical reports through printed indexes (16%) and computerized bibliographic searches (12%). Similar results are observed for methods of identifying journal articles by DOE funded scientists and engineers where browsing (42%), colleagues (18%) and citations in articles (15%) account for most of the reading. However, seven percent of the article readings were identified through printed indexes and 18 percent through computerized bibliographic searches.

A survey across all scientists and engineers suggests that they do not identify technical reports as frequently through bibliographic services and products (5% printed indexes, 4% computerized searches) as do the DOE funded scientists and engineers (16% and 12% respectively). These proportions for the entire population of scientists and engineers were six and three percent respectively, which confirms the evidence that the DOE funded scientists and engineers search bibliographic publications and online databases much more frequently than other scientists and engineers.

The age of technical reports and journal articles through various methods of identification are given in Tables 10 through 13. The average age of items identified through printed indexes is 1.0 and 1.2 years for technical reports and journal articles respectively, while the average age of items read from computerized bibliographic searches is 2.4 and 4.3 years for technical reports and journal articles. This may suggest that printed indexes are used more for current awareness (or at least for searching recent bibliographic publications) and computerized bibliographic searches for identifying older materials. The ages of the items read from computerized searches compares reasonably closely with the items identified through citations in technical reports, journal articles, etc.

The results suggest that a fair amount of reading comes from newly published materials identified from bibliographic services and publications. In fact, with DOE-funded scientists and engineers, this number is estimated to be about 350,000 readings of technical reports and 550,000 journal articles each year. Thus, speed of making bibliographic materials

Table 10

Proportion of Technical Reports Read by Age
by Method of Identification - May 1984

(%)

Year Published	All Readings	Method of Identification: Routed	Library Accession List	Colleague	Cited in Technical Reports	Printed Index	Computer Search	Other
1984	51%	63%	56%	47%	30%	33%	-	69%
1983	23	23	11	29	30	33	20	15
1982	9	8	11	6	5	17	20	8
1980-81	9	4	-	8	10	17	60	4
1975-79	3	-	-	2	20	-	-	4
1970-74	3	-	11	4	-	-	-	-
<1970	2	3	11	4	5	-	-	-
Total	100	101	100	100	100	100	100	100
Average Age (Yrs)	1.4	0.9	3.2	1.8	2.5	1.0	2.4	0.7

SOURCE: King Research, Inc. Survey of Scientists and Engineers (n=195)

Table 11

Proportion of Technical Reports Read by Method of Identification by Age - May 1984

(%)

Year Published	All Readings	Method of Identification: Routed	Library Accession List	Colleague	Cited in Technical Reports	Printed Index	Computer Search	Other	Total
1984	51%	25	6	30	7	3	-	29	101
1983	24%	20	2	41	14	6	2	14	99
1982	8%	21	7	26	7	10	7	22	100
1980-81	8%	11	-	34	15	9	20	11	100
1975-79	4%	-	-	37	60	-	-	3	100
1970-74	2%	-	30	70	-	-	-	-	100
<1970	3%	20	19	43	18	-	-	-	100
Average Age (Yrs)	1.4	0.7	3.2	1.8	2.5	1.0	2.4	0.7	

SOURCE: King Research, Inc. Survey of Scientists and Engineers (n=195)

Table 12

Proportion of Journal Articles Read by Age
by Method of Identification - May 1984

(%)

Year Published	Read-ings	Method of Identification					
		Browsing	Colleague	Cited in Article, etc.	Printed Index	Computer Search	Other
1984	71%	90%	42%	20%	63%	19%	75%
1983	12	7	24	13	24	25	10
1982	4	1	7	11	5	12.5	6
1980-81	4	0.6	10	14	5	12.5	6
1975-79	5	1	10	24	0	12.5	3
1970-74	2	-	3.5	9	3	12.5	-
<1970	2	0.4	3.5	9	0	6	3
Total	100	99	100	100	100	100	103
Average Age (Yrs.)	1.3	1.0	2.4	5.2	1.2	4.3	1.2

SOURCE: King Research, Inc. Survey of Scientists and Engineers (n=664)

Table 13

Proportion of Journal Articles by
Method of Identification by Age - May 1984

(%)

Year Published	All Read-ings	Method of Identification						
		Browsing	Colleague	Cited in Article, etc.	Printed Index	Computer Search	Other	Total
1984	68%	66	10	4	6	1	13	100
1983	12%	28	30	14	12	6	10	100
1982	4%	11	25	33	7	9	14	99
1980-81	5%	6	30	37	6	10	12	101
1975-79	6%	8	26	53	0	7	6	100
1970-74	2%	-	23	52	8	17	-	100
<1970	3%	8	22	47	-	8	15	100
Average Age (Yrs.)	1.3	1.0	2.4	5.2	1.2	4.3	1.2	

SOURCE: King Research, Inc. Survey of Scientists and Engineers (n=664)

available must be quite good, but some improvement could possibly be made. If one could increase the publication time by, say, two months, the number of unique readings might increase by as much as 24,000 for technical reports, and 14,000 for journal articles. Value of these readings, in terms of willingness to pay, could be about $3 million for the two together and $22 million in savings.

2.5 The Effect of Delays in Conducting Bibliographic Searches on the Value of Information

Many bibliographic searches are performed by reference librarians (information scientists) for DOE (and other) scientists and engineers. Another aspect of timeliness that can affect value is the speed with which searches are conducted for the end users. In Volume 1, The Value of Library Services, we did an in-depth analysis of this aspect of timeliness. In that analysis, we developed a statistical model (conjoint measurement) which provided a means of analyzing the trade-off of speed of response and level of relevance in terms of the value end users would be willing to pay measured in their time and, hence, dollars. The results of this trade-off analysis are displayed in Figures 1 and 2.

Figure 1 shows the relative trade-off for manual searches of speed of response (between immediate and four days) and level of relevance of the search output. Generally, the reduction in willingness to pay value per one day increase in response time is about $6.50. We estimate that the average response time is about 5 days. If this time could be reduced by one-half, the value (in willingness to pay) would increase by about $16 per search. Over all manual searches performed for DOE funded scientists and engineers, this would come to about $5 million. For computerized bibliographic searches (Figure 2), the reduction in willingness to pay value per one day increase in response time is about $8.50. The average response time is 3.7 days. If this time could be reduced by one-half, the value (in willingness to pay) would also increase by about $16 per search or about $3 million altogether for all searches.

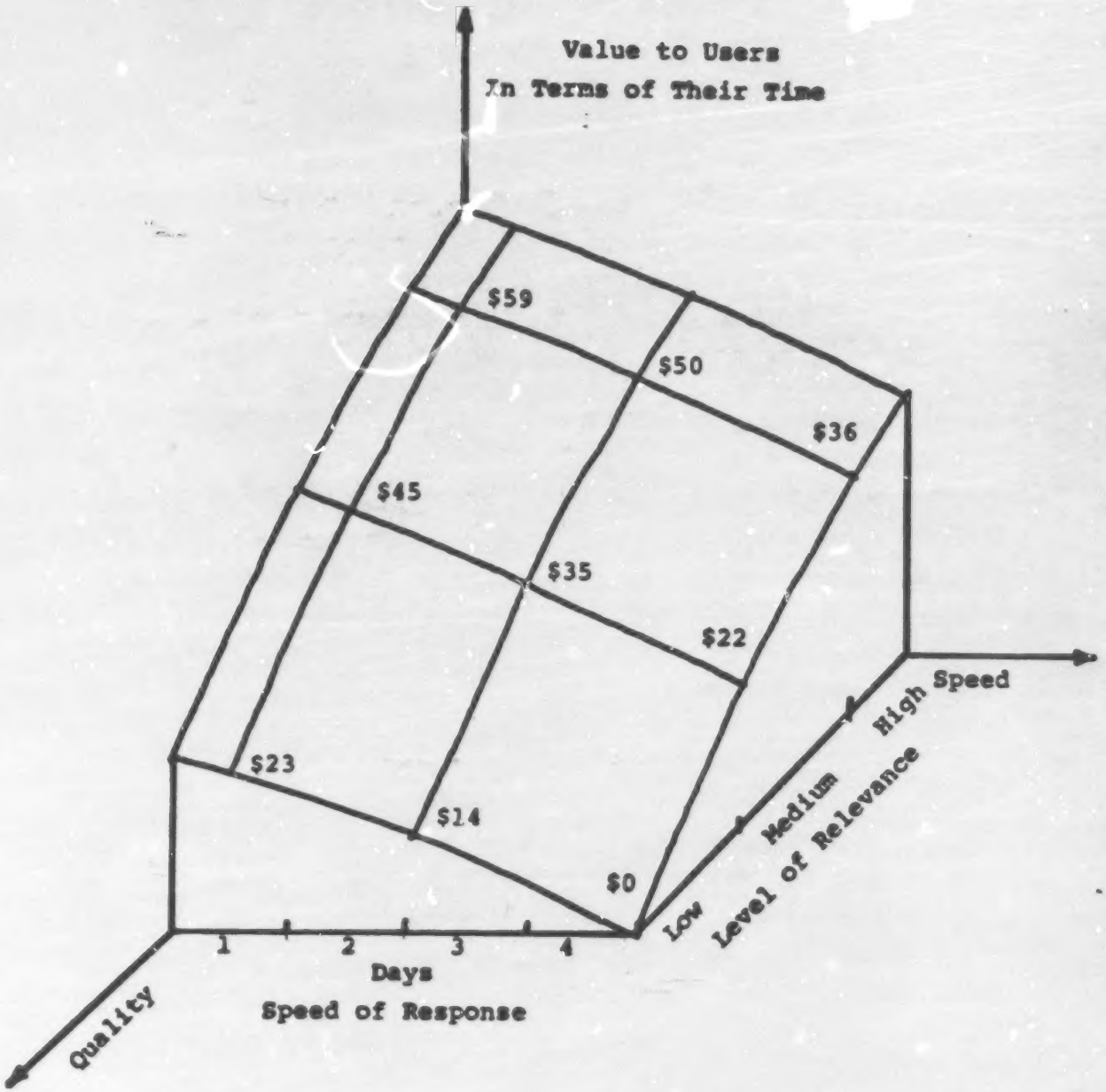

Figure 1: Value of Manual Searches to Relationship of Level of Relevance and Speed of Response

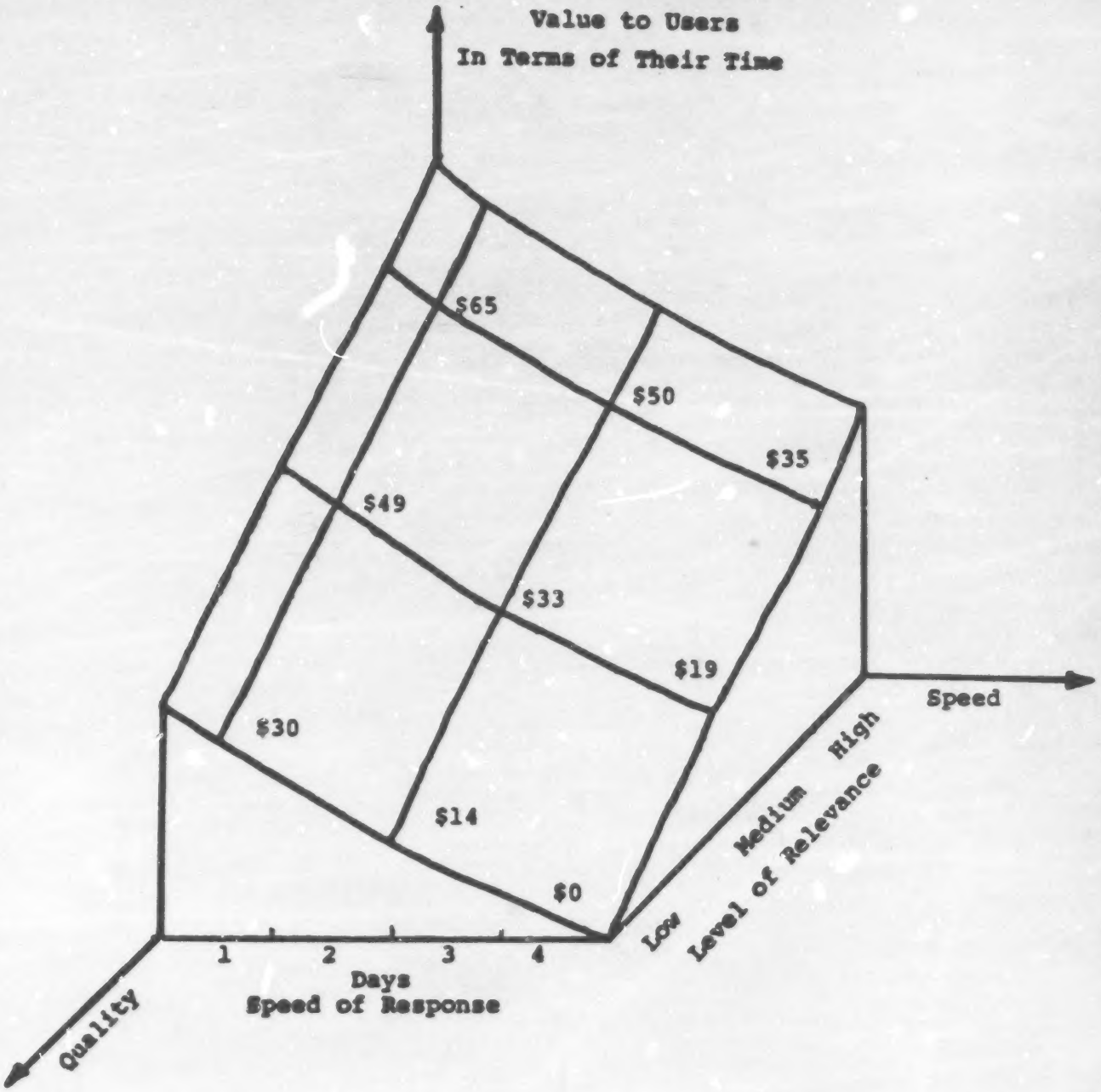

Figure 2: Relationship of Value of Online Searches to Level of Relevance and Speed of Response

SECTION 3

VALUE OF COMPREHENSIVENESS OF THE ENERGY DATA BASE

3.1 Background

In this section, we examine the comprehensiveness of the Energy Data Base from the standpoint of non-U.S. materials. Of all the readings, it is estimated that about 13 percent of the technical report readings and 15 percent of the journal article readings are from non-U.S. materials. The distribution of these readings over various countries is as follows:

Table 14

Proportion of Technical Report and Journal Article Readings That Are Published in Non-U.S. Countries

(%)

Country	Technical Report Readings*		Journal Article Readings**	
	All Readings	Non-U.S.	All Readings	Non-U.S.
Canada	2.3%	18%	2.0%	13%
United Kingdom	2.3	18	5.1	34
France	—	—	0.6	4
Germany	1.6	12	2.1	14
Japan	1.6	12	1.5	10
Russia	0.8	6	0.5	3
Other	4.6	35	3.5	23

SOURCE: King Research, Inc. Survey of Scientists and Engineers (n^{*}=195, n^{**}=664)

It is clear that the English-speaking countries account for a large portion of the non-U.S. reading, but Germany and Japan also account for about ten to 15 percent each.

It was found that the readers knew about the research prior to reading non-U.S. materials in about the same proportions as U.S. materials. For example, in about 53 percent of the readings of non-U.S. technical reports, the reader knew about the research compared with about 59 percent for U.S. technical reports. For journal article readings, this proportion of knowledge of research was 44 percent for non-U.S. and 45 percent for U.S. articles. However, the information in the materials is found to be unique more frequently for non-U.S. materials than U.S. materials. For example, about three-fourths of the non-U.S. technical reports are found to be unique compared to 63 percent of the U.S. technical reports, and 81 percent of the non-U.S. journal articles are found to be unique versus 67 percent for the U.S. articles. This suggests that there might be some increase in value for an average reading of non-U.S. technical reports and journal articles.

In terms of savings derived from having read the non-U.S. materials, we estimate that about nine percent of the non-U.S. technical report readings had savings compared to 48 percent for U.S. technical reports. On the other hand, about 20 percent of the non-U.S. journal article readings yielded savings compared to 25% for U.S. journal articles. Applying these data to readings by DOE-funded scientists and engineers, we estimate that there are about 300,000 unique non-U.S. technical report readings that yielded savings and 480,000 unique non-U.S. journal article readings that resulted in savings. The next question is how many of these readings resulted from searching the Energy Data Base, either through the Energy Research Abstracts or RECON.

Applying the proportion of readings attributable to searches from the EDB, we estimate that the number of unique non-U.S. technical report readings identified from the EDB (ERA and RECON) that yield savings is about 34,000 and the number of unique non-U.S. journal article readings tha yield savings is 54,000. The total values in terms of willingness to pay

are $3.5 million and $1.9 million for technical report and journal article readings, respectively. The total savings values are $24 million for non-U.S. technical report readings and $21 million for non-U.S. journal article readings. When substitutions are considered the total value of non-U.S. reading comes to $2 million in willingness to pay and $17 million in savings value. Total non-U.S. material readings from the EDB are 240,000 technical report readings and 120,000 journal article readings, or about four non-U.S. technical report readings per DOE-funded scientist or engineer per year, and two non-U.S. journal article readings per year.

Of some interest is how general scientists and engineers identify and gain access to non-U.S. materials. This data is summarized in Table 15 below.

Table 15
Proportion of Readings of Technical Reports and Journal Articles Identified by Various Methods by U.S. and non-U.S. Materials - 1984

(%)

Identification Methods	Technical Reports*		Journal Articles**	
	U.S.	Non-U.S.	U.S.	Non-U.S.
Browsing	—	—	55%	18%
Routing	21%	21%	—	—
Library Accessions List	6%	0%	—	—
Colleague	34%	29%	15%	18%
Cited in Other Materials	10%	21%	11%	26%
Printed Index	4%	7%	6%	7%
Computerized Search	2%	7%	2%	10%
Other	23%	14%	11%	21%
Total	100	100	6,035,000	1,065,000

SOURCE: King Research, Inc. General Survey of Scientists and Engineers (n^{*}=195, n^{**}=644)

It is evident that non-U.S. technical reports are more likely to be found in citations and bibliographic materials than are the U.S. technical materials. On the other hand, read non-U.S. journal articles are much less likely to be found by browsing than read U.S. journal articles.

SECTION 4

CROSS-CUTTING USE OF INFORMATION MATERIALS

4.1 Cross-cutting Use of Materials

The Energy Data Base covers a wide range of subject areas. A question arises about whether such wide-ranging materials should be covered. A small study was performed to provide some evidence concerning this issue. This study involved 21 actual computerized bibliographic searches performed by Department of Energy-funded scientists and engineers. The scientists or engineers were asked to describe the project for which they were searching. They also specified the topics of their search. At a later time, subject experts from OSTI were asked to classify the project descriptions to provide a comparison of the subject area of the project and the searches that were performed. It turns out that the matching of project subjects and search subjects is only partially common. The proportion of overlap is shown in the Venn diagram in Figure 3 below.

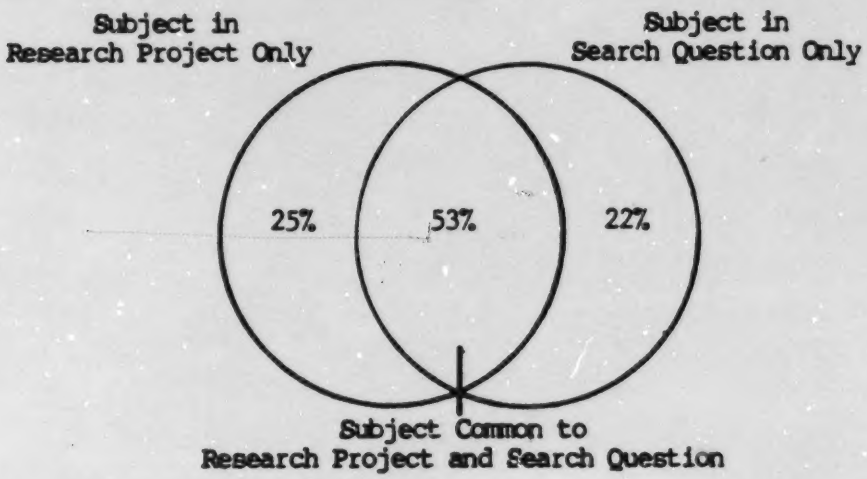

Figure 3 Overlap of Subjects Found in Research Project Title and Search Questions (n=21)

A little more than one-half of the subject classifications were common to both; thus, it would appear that a greater coverage of subject areas is needed.

Another indication is the usefulness of the items retrieved in the searches. The end-users were asked to indicate (1) which items on the print-out were of interest to them in terms of the specific research project (for which the search was conducted), (2) the other items that were also of general interest to them, and (3) the items that they had read or intended to read. These items were inspected by OSTI and KRI to determine how many items fell into the classes above. The results of the 21 searches are given in Table 14. Summary of results from the table are as follows:

- There was an average of 24 items identified per search (hits)
- Of these, an average of 12.8 were read (or intended to be read)
- An average of 11.8 of the items identified were thought to be relevant to the research project and 7.2 of these were read
- An average of 12 of the items identified were also of general interest to the scientists and engineers and 2.4 of these were read.

Thus, not only are the subject areas of search different than the research project, but they yield a number of items that are read for the research project as well as for general interest.

The individual items retrieved that were (1) relevant and (2) read were also examined to see if they were U.S. or non-U.S. publications. Of items that were judged by the users to be relevant to their research project and of general interest, it was found that 20 percent of both categories were non-U.S. publications. This compares to 13 percent for technical reports and 15 percent for journal articles observed in the general survey of scientists and engineers. The proportion read is about eight percent non-U.S. Again, this is supporting evidence that the scientists and engineers funded by DOE tend to use non-U.S. materials more frequently than other scientists and engineers.

Table 16

Number of Items Retrieved, Read and Relevant to Project and General Interest by U.S. and Non-U.S. Materials - 1984

Search Number	Total	Research Project		General Interest		Read	
		U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.
1	85	8	1	4	1	9	1
2	40	3	4	10	11	7	4
3	33	9	3	11	3	6	1
4	59	3 total*		59 total*		13 total*	
5	60	6	6	23	7	14	3
6	72	17	25	1	3	3	2
7	47	3	1	3	1	11	1
8	61	11	-	11	-	15	-
9	35	10	-	-	-	10	-
10	63	27	-	18	3	2	-
11	128	1	-	5	-	5	-
12	31	9	-	7	-	10	-
13	29	4	-	12	7	9	-
14	20	8	1	2	1	4	1
15	15	7	-	9	-	12	-
16	28	4	-	1	-	7	-
17	11	7	-	-	-	7	-
18	30	3	-	7	1	1	-
19	92	39	7	5	1	37	3
20	249	17	3	9	1	32	5
21	124	1	-	15	-	35	-

* Breakdown by U.S. and non-U.S. not available

SOURCE: King Research, Inc.-Survey of Online Bibliographic Searches (n=21)